The D. H. Hill Library

North Carolina State
College

This book was presented
by
W.H. Browne, Jr
T61
S6
v.16
1908

NORTH CAROLINA STATE UNIVERSITY LIBRARIES
S01846546 Y

41574

T61
S6
v.16
1908

Soc

DATE

Library Bureau

This BOOK may be kept out TWO WEEKS ONLY, and is subject to a fine of FIVE CENTS a day thereafter. It is due on the day indicated below:

41574

Digitized by the Internet Archive
in 2010 with funding from
NCSU Libraries

http://www.archive.org/details/engineeringeduca16soci

Society
FOR THE
Promotion of Engineering Education

PROCEEDINGS
OF THE
SIXTEENTH ANNUAL MEETING
HELD IN
DETROIT, MICH., JUNE 24-27, 1908

Volume XVI

EDITED BY
CHARLES S. HOWE FREDERICK E. TURNEAURE
ARTHUR L. WILLISTON

BROOKLYN, N. Y.
OFFICE OF THE SECRETARY
PRATT INSTITUTE
1909

PRESS OF
THE NEW ERA PRINTING COMPANY
LANCASTER, PA

TABLE OF CONTENTS.

PAGE.
List of Officers vii
List of Standing Committees vii
List of Members of the Council viii
List of Members ix
Geographical Distribution of Members liii
Geographical Summary of Members lviii
List of Institutions Represented lix
Summary of Members by Occupations lxii
General Summary lxii
Deceased Members lxiii
Past Officers lxiv
Members of Previous Councils lxv
Constitution lxvii
By-Laws and Rules Governing Council lxix
Publications lxx
Report of the Proceedings of the Sixteeth Annual Meeting 1
    Report of the Auditing Committee 4
    Report of the Nominating Committee 8
    Report of the Committee on Resolutions 9
    Report of the Secretary 9
    Report of the Treasurer 11
    List of Persons Elected to Membership 13
Address of Welcome.—**Mayor Thompson of Detroit** 16
Response.—**Vice President William G. Raymond** 19
Presidential Address—The Function of the Engineer in the Conservation of the Natural Resources of the Country. —**Charles S. Howe** 20
Preliminary Report of the Joint Committee on Engineering Education.—**Samuel Sheldon and D. C. Jackson**............ 47
The Courses in English in our Technical Schools.—**J. Martin Telleen** 61
Results of an Experiment in Teaching Freshman English. —**William Kent.** 74
    Joint Discussion 84
A Proposed Course in General Engineering.—**Harwood Frost**.. 98
Mechanical Engineering Curriculums.—**William T. Magruder** 113
    Discussion 119
Adapting Means to the Ends in Technical Education.—**Arthur L. Rice** 121

41574

PAGE.
THE CORRELATION OF COURSES IN ENGINEERING COLLEGES.—**Gardner C. Anthony** 126
THE PLACE OF MODERN LANGUAGES IN THE CURRICULUM OF THE SCHOOL OF ENGINEERING.—**Arthur S. Wright** 136
DISCUSSION 157
SECOND DEGREES FOR GRADUATES OF ENGINEERING COURSES.—**William F. M. Goss** 159
SCHOLASTICISM IN ENGINEERING EDUCATION.—**John Price Jackson** 162
DISCUSSION 173
TECHNICAL INSTRUCTION IN HYDRAULIC ENGINEERING.—**Daniel W. Mead** 174
DISCUSSION 199
ELECTRICAL LABORATORY EQUIPMENT AND EFFICIENCY.—**S. Sumner Edmands** 202
CEMENT LABORATORY PRACTICE.—**Ira O. Baker** 216
DISCUSSION 236
HOW FAR IS PURE THERMODYNAMICS OF VALUE IN PREPARING STUDENTS FOR HANDLING MECHANICAL ENGINEERING PROBLEMS.—**Arthur J. Wood** 238
DISCUSSION 246
ON ENTROPY.—**William D. Ennis** 249
ON THE CONCENTRIC METHOD OF EDUCATION IN ENGINEERING.—**V. Karapetoff** 258
DISCUSSION 277
TWO YEARS OF THE COOPERATIVE ENGINEERING COURSES AT THE UNIVERSITY OF CINCINNATI.—**Herman Schneider** 279
DISCUSSION 294
CAREERS OF GRADUATES IN MECHANICAL ENGINEERING.—**Franklin DeR. Furman** 307
DISCUSSION 337
THE USE, ABUSE AND CARE OF LANTERN SLIDES.—**Henry H. Norris.** 343
SHOULD THE ENGINEER BE REQUIRED TO HOLD LICENSE?—**Walter H. Drane** 350
DISCUSSION 362
REPORT OF COMMITTEE ON INDUSTRIAL EDUCATION.—**Arthur L. Williston, Secretary** 363
NECROLOGY. ON CHARLES S. MAGOWAN 406
ON STORM BULL 407
ON CHARLES P. MATTHEWS 408
ON WILLIAM A. ANTHONY 409
INDEX 410

OFFICERS

OF THE

Society for the Promotion of Engineering Education

1908—1909

PRESIDENT

FREDERICK E. TURNEAURE, University of Wisconsin, Madison, Wis.

VICE-PRESIDENTS

MORTIMER E. COOLEY, University of Michigan, Ann Arbor, Mich.
OLIN H. LANDRETH, Union University, Schenectady, N. Y.

SECRETARY

ARTHUR L. WILLISTON, Pratt Institute, Brooklyn, N. Y.

TREASURER

WILLIAM O. WILEY, 43 E. 19th St., New York, N. Y.

STANDING COMMITTEES

On Entrance Requirements for Engineering Colleges

J. J. FLATHER, *Chairman.*
J. P. JACKSON, MANSFIELD MERRIMAN, C. D. MARX, F. W. MCNAIR, F. O. MARVIN, J. C. NAGLE, R. B. OWENS, W. D. PENCE.

On Statistics of Engineering Education

W. T. MAGRUDER, *Chairman*, L. E. REBER, A. N. TALBOT, H. W. TYLER, The President and the Secretary.

On Industrial Education

C. M. WOODWARD, *Chairman*, HENRY T. EDDY, G. F. SWAIN, G. A. GOODENOUGH, A. L. WILLISTON, W. B. RUSSELL.

On Technical Books for Libraries

A. H. FORD, *Chairman*, H. K. VEDDER, H. O. HOFMAN, JAMES FISHER, JR., J. H. HAWES, F. H. CONSTANT.

Representatives of S. P. E. E. on Joint Committee on Engineering Education

D. C. JACKSON, *Chairman*, S. SHELDON, *Secretary*, A. C. HUMPHREYS.

COUNCIL

ELECTIVE MEMBERS

Terms of Office Expire in 1909

Milo S. Ketchum, University of Colorado,
John F. Hayford, Coast and Geodetic Survey,
Henry H. Norris, Cornell University,
Charles F. Burgess, University of Wisconsin,
Joseph A. Thaler, Montana College of Agriculture and Mechanic Arts,
Arthur M. Greene, Jr., Rensselaer Polytechnic Institute,
Thomas W. Palmer, Alabama Girls' Industrial School.

Terms of Office Expire in 1910

Fred W. Atkinson, Polytechnic Institute of Brooklyn,
Mortimer E. Cooley, University of Michigan,
William S. Franklin, Lehigh University,
William Kent, The Sandusky Foundry and Machine Company,
Walter B. Russell, Franklin Union,
Charles F. Scott, Westinghouse Electric and Manufacturing Company,
Harold B. Smith, Worcester Polytechnic Institute.

Terms of Office Expire in 1911

Lester P. Breckenridge, University of Illinois,
*Thomas Gray, Rose Polytechnic Institute,
Lewis J. Johnson, Harvard University,
William T. Magruder, Ohio State University,
William G. Raymond, State University of Iowa,
Herman Schneider, University of Cincinnati,
Clarence A. Waldo, Washington University.

Members Ex-Officiis

George F. Swain,
Mansfield Merriman,
Henry T. Eddy,
Thomas C. Mendenhall,
Ira O. Baker,
Frank O. Marvin,
Robert Fletcher,
Calvin M. Woodward,
C. Frank Allen,
Fred W. McNair,
Charles L. Crandall,
Dugald C. Jackson,
Charles S. Howe,
Frederick E. Turneaure,
Mortimer E. Cooley,
Olin H. Landreth,
Arthur L. Williston,
William O. Wiley.

---

* Deceased December 19, 1908.

List of Members.

(Including all members on Secretary's books at close of Annual Meeting, 1908.)

Name and Address.	Title.	Date of Membership.
Abbott, Frederick B. 482 7th St., Brooklyn, N. Y.	Columbia University	1904
Adams, Charles L. Boston, Mass.	Associate Professor of Drawing and Descriptive Geometry, Massachusetts Institute of Technology	1904
Adams, Comfort A. Cambridge, Mass.	Professor of Electrical Engineering, Harvard University	1894
Adams, Lee Francis State College, Pa.	Instructor in Electrical Engineering, Pennsylvania State College	1907
Alderson, Victor C. Golden, Colo.	President, Colorado School of Mines	1900
Aldrich, William S. Potsdam, N. Y.	Director, Clarkson School of Technology	1893
Allen, C. Frank Boston, Mass.	Professor of Railroad Engineering, Massachusetts Institute of Technology	1893
Allen, Charles M. 10 Dean St., Worcester, Mass.	Professor of Experimental Engineering, Worcester Polytechnic Institute.	1903
Allen, John R. 226 South Ingalls St., Ann Arbor, Mich.	Professor of Mechanical Engineering, University of Michigan	1907
Anderson, Douglas S. New Orleans, La.	Professor of Electrical Engineering, Tulane University	1900
Anderson, F. Paul Lexington, Ky.	Director, College of Mechanical and Electrical Engineering; Professor of Mechanical Engineering, State University of Kentucky	1894
Anthony, Gardner C. Tufts College, Mass.	Professor of Technical Drawing and Dean of the Department of Engineering, Tufts College	1896
Appleton, William Day Apartado 23, Zamora, Michoacan, Mexico.	Mechanical Engineer, The Guanajuato Power and Electric Co.	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
APPLEYARD, LOUIS L. 417 Ottowa St., East Lansing, Mich.	Assistant Professor of Mechanical Engineering, Michigan Agricultural College	1907
ARKLEY, LORNE M. 308 N. Edgemont St., Media, Pa.	Assistant Professor of Engineering, Swarthmore College	1908
ARNOLD, BION J. Chicago, Ill.	Consulting Electrical Engineer, 1539 Marquette Building	1896
ATKINSON, FRED W. 55 Pineapple St., Brooklyn, N. Y.	President of the Polytechnic Institute of Brooklyn	1905
ATKINSON, THOMAS W. Baton Rouge, La.	Professor of Physics and Electricity, Louisiana State University	1907
ATWOOD, JAMES T. 929 Spaight St., Madison, Wis.	Manufacturer of Atwood Vacuum Cleaner	1908
AUSTIN, LEONARD S. Houghton, Mich.	Professor of Metallurgy, Michigan College of Mines	1905
AYARS, WILLIAM S. Box 302, State College, Pa.	Associate Professor of Machine Design, The Pennsylvania State College	1907
AYER, ARTHUR W. 3403 Gray's Ferry Road, Philadelphia, Pa.	General Superintendent, Harrison Bros. & Co., Inc.	1894
AYER, FREDERIC E. 288 Ludlow Ave., Cincinnati, Ohio.	Assistant Professor of Civil Engineering, University of Cincinnati	1907
AYRES, BROWN Knoxville, Tenn.	President of the University of Tennessee	1898
BABCOCK, EARLE J. State University, Grand Forks, N. D.	Dean of the College of Mining Engineering and Professor of Chemistry and Metallurgy, State University and School of Mines of North Dakota	1907
BABCOCK, WARREN East Lansing, Mich.	Associate Professor of Mathematics, Michigan Agricultural College	1908
BACON, GEORGE M. 159 Pierpont Ave., Salt Lake City, Utah.	Civil Engineer	1907
BAKER, IRA O. Champaign, Ill.	Professor of Civil Engineering, University of Illinois	1893

Name and Address.	Title.	Date of Membership.
Ball, Albert Cooper Union, New York, N. Y.	Assistant Professor of Physics and Mechanical and Electrical Engineering, Cooper Union for the Advancement of Science	1908
Ballard, Frederick W. 49 Cadwell Ave., Mayfield Heights, Cleveland, Ohio.	Manager of Engineering and Construction Department, The Sherwin-Williams Co.	1907
Ballou, Willard A. Brooklyn, N. Y.	Instructor in Mathematics, Pratt Institute of Brooklyn	1908
Barnes, Fred A. Ithaca, N. Y.	Assistant Professor of Railroad Engineering, Cornell University	1904
Barney, Samuel E. New Haven, Conn.	Assistant Professor of Civil Engineering, Yale University	1894
Barr, John H. Syracuse, N. Y.	Smith Premier Works	1902
Barraclough, S. Henry Sydney, N. S. W., Australia.	Professor of Mechanical Engineering, Russell School of Engineering, University of Sydney	1900
Barrows, Harold K. 6 Beacon St., Boston, Mass.	Hydraulic and Sanitary Engineer	1902
Barrows, William E., Jr. Chicago, Ill.	Assistant Professor of Electrical Engineering, Armour Institute of Technology	1908
Barton, Samuel M. Sewanee, Tenn.	Professor of Mathematics, University of the South	1904
Basquin, Olin H. Evanston, Ill.	Associate Professor of Physics, Northwestern University	1908
Bass, Frederic H. Minneapolis, Minn.	Assistant Professor of Civil Engineering, University of Minnesota	1904
Bates, Erastus N. East Lansing, Mich.	Instructor in Electrical Engineering, Michigan Agricultural College	1908
Bates, Onward 355 Dearborn St., Chicago, Ill.	Civil Engineer	1903
Becker, Albert John 616 University Ave., Grand Forks, N. D.	Professor of Applied Mathematics and Mechanical Drawing, State University of North Dakota	1907
Beebe, Murray Charles Madison, Wis.	Professor of Electrical Engineering, University of Wisconsin	1906

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
BEMENT, A. 2114 Fisher Bldg., Chicago, Ill.	Mining and Mechanical Engineer	1907
BENCH, ALFRED R. 901 South Fifth St., Champaign, Ill.	Instructor in Mechanical Engineering, University of Illinois	1908
BENEDICT, HARRY YANDELL. Austin, Texas.	Professor of Applied Mathematics, University of Texas	1906
BENJAMIN, CHARLES H. Lafayette, Ind.	Dean of the Schools of Engineering, Purdue University	1893
BENTON, JOHN R. Gainesville, Fla.	Professor of Physics and Electrical Engineering, University of the State of Florida	1905
BENZENBERG, GEORGE H. 255 Greenbush St., Milwaukee, Wis.	Consulting Civil Engineer	1907
BETTS, PHILANDER The Oakland, 2019 Columbia Road, Washington, D. C.	Assistant Professor in Electrical Engineering, George Washington University, Washington College of Engineering	1907
BEYER, SAMUEL W. Ames, Iowa.	Professor of Geology and Mining Engineering, Iowa State College	1899
BIEGLER, PHILIP S. Iowa City, Iowa.	Assistant Professor of Electrical Engineering, State University of Iowa	1908
BISHOP, FREDERIC L. 210 Clara St., Peoria, Ill.	Assistant Professor of Physics and Head of the Department of Physics, Bradley Polytechnic Institute	1907
BISSELL, GEORGE W. East Lansing, Mich.	Dean of Engineering and Professor of Mechanical Engineering, Michigan Agricultural College	1894
BIXBY, WILLIAM H. 428 Custom House, St. Louis, Mo.	Colonel Corps of Engineers, U. S. Army, U. S. Engineer's Office	1898
BLACK, ADOLPH New York, N. Y.	Adjunct Professor of Civil Engineering, Columbia University	1907
BLANCHARD, ARTHUR H. Providence, R. I.	Associate Professor of Civil Engineering, Brown University	1902
BOARDMAN, HAROLD S. Orono, Me.	Professor of Civil Engineering, University of Maine	1903
BOHANNAN, ROSSER D. Indianola and 16th Aves., Columbus, Ohio.	Professor of Mathematics, Ohio State University	1907

Name and Address.	Title.	Date of Membership.
Boothroyd, Samuel L. Forest Home, Ithaca, N. Y.	Assistant Professor of Topographic and Geodetic Surveying, Cornell University	1908
Boughton, Will H. Morgantown, W. Va.	Professor of Civil Engineering, West Virginia University	1905
Bovey, Henry T. Montreal, Quebec.	Dean of the Faculty of Applied Science, Professor of Civil Engineering and Applied Mechanics, McGill University	1893
Boyd, James E. 92 West Lane Ave., Columbus, Ohio.	Professor of Mechanics, Ohio State University	1907
Brackett, Byron B. Potsdam, N. Y.	Professor of Electrical Engineering, Thomas S. Clarkson Memorial School of Technology	1906
Bradbury, Royall Douglas Technology Chambers, Boston, Mass.	Instructor in Civil Engineering, Massachusetts Institute of Technology	1907
Bradford, Joseph N. Columbus, Ohio.	Professor of Architecture, Ohio State University	1896
Bray, Charles D. Tufts College, Mass.	Professor of Mechanical Engineering, Tufts College	1894
Breckenridge, Lester P. Urbana, Ill.	Professor of Mechanical Engineering and Director of Engineering Experiment Station, University of Illinois.	1893
Breed, Charles B. Boston, Mass.	Assistant Professor of Civil Engineering, Massachusetts Institute of Technology	1904
Brill, George M. 1134 Marquette Bldg., Chicago, Ill.	Consulting Engineering	1894
Brinsmade, Robert Bruce. 4429 Morgan St., St. Louis, Mo.	Consulting Engineer	1907
Brooke, William E. Minneapolis, Minn.	Professor of Mathematics, College of Engineering, University of Minnesota	1902
Brooks, J. Ansel. Providence, R. I.	Assistant Professor of Mechanics and Mechanical Drawing, Brown University	1904
Brooks, John P. Urbana, Ill.	Associate Professor and (1908–9) Acting Head Department of Civil Engineering, University of Illinois.	1898

Name and Address.	Title.	Date of Membership.
Brooks, Morgan Urbana, Ill.	Professor of Electrical Engineering, University of Illinois	1899
Brown, J. Stanford 10 Belmont Ave., Yonkers, N. Y.	Vice-President and Treasurer, New York Realty Owners, 489 Fifth Ave., New York City	1903
Brown, N. H. College Station, Texas.	Professor of Physics and Electrical Engineering, Agricultural and Mechanical College of Texas	1904
Brown, Robert L. P. O. Box "O," Auburn, Ala.	Professor of Mining and Geology, Alabama Polytechnic Institute	1908
Browne, Wm. Hand, Jr. West Raleigh, N. C.	Professor of Physics and Electrical Engineering, North Carolina College of Agriculture and Mechanic Arts	1899
Bruegel, A. Theodore Philadelphia, Pa.	Engineer and Office Manager, The Hesse-Bright Mfg. Co., 21st and Fairmount Ave., Philadelphia, Pa.	1900
Brydone-Jack, Ernest E. Winnipeg, Manitoba.	Professor of Civil Engineering, University of Manitoba	1902
Bump, Milan R. 60 Wall St., New York, N. Y.	Secretary, Doherty Operating Company	1907
Burger, Charles R. Golden, Colo.	Professor of Mathematics, Colorado School of Mines	1904
Burgess, Charles F. Madison, Wis.	Professor of Applied Electro-chemistry, University of Wisconsin	1896
Burnham, Raymond 3606 Prairie Ave., Chicago, Ill.	Associate Professor of Experimental Engineering, Armour Institute of Technology	1904
Burr, William H. New York, N. Y.	Professor of Civil Engineering, Columbia University	1893
Burton, Alfred E. Boston, Mass.	Professor of Topographical Engineering, in charge of Department of Drawing, and Dean, Massachusetts Institute of Technology	1904
Butterfield, Arthur D. 10 Schussler Road, Worcester, Mass.	Assistant Professor of Mathematics, Worcester Polytechnic Institute	1908
Cajori, Florian 1119 Wood Ave., Colorado Springs, Colo.	Professor of Mathematics and Dean of School of Engineering, Colorado College	1904

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
CALDWELL, EDWARD 239 West 39th St., New York, N. Y.	Manager, Book Department, McGraw Publishing Co., New York City	1905
CALDWELL, FRANCIS C. Columbus, Ohio.	Professor of Electrical Engineering, Ohio State University	1897
CAMP, WALTER M. 7740 Union Ave., Chicago, Ill.	Editor of *Railway and Engineering Review*	1904
CARHART, DANIEL Wilkinsburg Station, Pittsburg, Pa.	Civil Engineer	1902
CARPENTER, LOUIS G. Fort Collins, Colo.	Professor of Civil and Irrigation Engineering, Director of Experiment Station, Colorado State Agricultural College	1895
CARPENTER, ROLLA C. Ithaca, N. Y.	Professor of Experimental Engineerin, Cornell University	1893
CARSON, WILLIAM W. Knoxville, Tenn.	Professor of Civil Engineering, University of Tennessee	1894
CARTY, JOHN JOSEPH Short Hills, N. J.	Chief Engineer American Telephone and Telegraph Co., 15 Dey Street, New York City	1907
CHANDLER, CLARENCE A. 24 Milk St., Boston, Mass.	Construction Engineer, Penn Mutual Building	1902
CHANDLER, ELWYN F. University, N. D.	Professor of Mathematics, University of North Dakota	1907
CHANUTE, OCTAVE 61 Cedar St., Chicago, Ill.	Consulting Engineer	1907
CHASE, CHARLES H. 39 Lincoln St., Stoneham, Mass.	Professor of Steam Engineering, Tufts College	1900
CHATBURN, GEORGE R. Lincoln, Neb.	Professor of Applied Mechanics and Machine Design, University of Nebraska	1899
CHITTENDEN, RUSSELL H. 83 Trumbull St., New Haven, Conn.	Director of the Sheffield Scientific School of Yale University	1908
CHRISTENSEN, GEORGE L. Houghton, Mich.	Assistant Professor of Mechanical Engineering, Michigan College of Mines.	1905

Name and Address.	Title.	Date of Membership.
Christy, Samuel B. Berkeley, Cal.	Professor of Mining and Metallurgy, University of California	1893
Clark, Addison Niel Luning, Nev.	Chief Engineer, Arizona-Nevada Gold Mining and Milling Company	1907
Clark, John J. 919 Sunset St., Scranton, Pa.	Dean of the Faculty, International Correspondence Schools; Manager Textbook Department International Textbook Company	1906
Clifford, Harry E. 20 Crystal St., Newton Center, Mass.	Professor of Theoretical and Applied Electricty, Massachusetts Institute of Technology	1907
Clifton, Harry T. 871 North Lake Ave., Pasadena, Cal.	Assistant Professor of Physics, Throop Polytechnic Institute	1907
Cobb, Herbert E. 1331 Adams St., Chicago, Ill.	Professor and Head of Department of Mathematics, Lewis Institute	1908
Cole, Arthur W. 224 Waldron St., West Lafayette, Ind.	Instructor in Mechanical Engineering, Purdue University	1908
Comstock, Elting H. 1530 Como Ave., S. E., Minneapolis, Minn.	Assistant Professor of Mathematics, The School of Mines, University of Minnesota	1907
Comstock, Frank Mason Cleveland, Ohio.	Professor of Descriptive Geometry, Case School of Applied Science	1907
Connelley, Clifford B. Osgood and Marepoe Aves., Allegheny, Pa.	Dean of the School for Apprentices and Journeymen, Carnegie Technical Schools, Pittsburg, Pa.	1907
Constant, Frank H. Minneapolis, Minn.	Professor of Structural Engineering, University of Minnesota	1896
Cooley, Mortimer E. Ann Arbor, Mich.	Professor of Mechanical Engineering and Dean of Department of Engineering, University of Michigan	1893
Copeland, Durward Houghton, Mich.	Instructor in Metallurgy, Michigan College of Mines	1905
Corthell, Elmer L. 1 Nassau St., New York, N. Y.	Civil Engineer	1895
Coulter, Stanley 302 Perrin Ave., Lafayette, Ind.	Professor of Biology and Director of Biological Laboratory, Purdue University	1904

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
COVELL, GRANT A. Corvallis, Ore.	Dean of School of Engineering and Mechanic Arts, Oregon Agricultural College	1908
COX, NELSON H. Gainesville, Fla.	Professor of Civil Engineering, University of the State of Florida	1903
CRANDALL, CHARLES L. Ithaca, N. Y.	Professor of Railroad Engineering, Cornell University	1893
CRANE, HAROLD G. Boston, Mass.	Instructor in Electrical Engineering, Massachusetts Institute of Technology	1908
CREIGHTON, WILLIAM H. New Orleans, La.	Professor of Mechanical Engineering, Tulane University	1893
CRENSHAW, BOLLING H. Auburn, Ala.	Professor of Mathematics, Alabama Polytechnic Institute	1894
CROUCH, CALVIN HENRY 513 South Sixth St., Grand Forks, N. D.	Professor of Mechanical Engineering and Dean of College of Mechanical and Electrical Engineering, The State University of North Dakota	1907
DALBURG, FRANK A. Manila, P. I.	Surveyor, Bureau of Lands	1908
DALTON, B. J. 1011 Indiana St., Lawrence, Kan.	Associate Professor of Railway Engineering, University of Kansas	1907
DATES, HENRY B. Cleveland, Ohio.	Professor of Electrical Engineering, Case School of Applied Science	1904
DAVIS, ELLERY W. Lincoln, Neb.	Dean of College of Literature, Science and the Arts, and Professor of Mathematics, University of Nebraska	1902
DEAN, ARTHUR D. Albany, N. Y.	Chief, Division of Trades Schools, N. Y. State Education Department	1907
DEFOE, LUTHER M. Columbia, Mo.	Professor of Mechanics, University of Missouri	1904
DENISON, CHARLES S. Ann Arbor, Mich.	Professor of Stereotomy, Mechanism and Drawing, University of Michigan	1893
DENTON, FREDERICK W. Painesdale, Mich.	General Manager of Mines, Copper Range Consolidated Company	1894
DENTON, JAMES E. Hoboken, N. J.	Professor of Engineering Practice, Stevens Institute of Technology	1893

Name and Address.	Title.	Date of Membership.
DePuy, Clarence E. 411 N. Elmwood Ave., Oak Park, Ill.	Professor of Machine Design and Construction, Lewis Institute, Chicago	1908
Derleth, Charles, Jr. Berkeley, Cal.	Professor of Civil Engineering, and Dean of the College of Civil Engineering, University of California	1904
Diemer, Hugo State College, Pa.	Professor of Mechanical Engineering, The Pennsylvania State College	1902
Dirks, Henry B. 901 South Fifth St., Champaign, Ill.	Instructor in Mechanical Engineering, University of Illinois	1908
Doherty, Henry L. 60 Wall St., New York, N. Y.	President, Denver Gas and Electric Company	1904
Dooley, Channing R. 735 Wallace Ave., Wilkinsburg, Pa.	Engineer, Westinghouse Electric and Mfg. Co., and President of Casino Technical Night School	1907
Drane, Walter H. University, Miss.	Dean of the Department of Engineering and Professor of Civil Engineering, University of Mississippi	1903
Drinker, Henry S. South Bethlehem, Pa.	President, Lehigh University	1905
Drowne, Henry B. Box 3, East Side Sta., Providence, R. I.	Instructor in Civil Engineering, Brown University	1908
Du Bois, A. Jay New Haven, Conn.	Professor of Civil Engineering, Yale University	1894
Dudley, Charles B. P. O. Drawer 156, Altoona, Pa.	Chemist, Pennsylvania Railroad Company	1894
Dufour, Frank O. Urbana, Ill.	Assistant Professor of Structural Engineering, University of Illinois	1906
Dukes, Richard G. 2257 Murray Hill Road, Cleveland, Ohio.	Assistant Professor of Applied Mechanics and Hydraulics, Case School of Applied Science	1907
Duncan, Louis 56 Pine St., New York, N. Y.	Consulting Electrical Engineer	1904
Duncan, Murray M. Ishpeming, Mich.	Agent, Cleveland Cliffs Iron Co., and Member Board of Control, Michigan College of Mines	1905

Name and Address.	Title.	Date of Membership.
Dunkin, William Van 607 West High St., Urbana, Ill.	Instructor in Machine Design, University of Illinois	1908
Durand, William F. Stanford University, Cal.	Professor of Mechanical Engineering, Leland Stanford Junior University	1899
Ebaugh, W. Clarence 208 Douglas Ave., Salt Lake City, Utah.	Professor of Chemistry, University of Utah	1908
Eddy, Henry T. Minneapolis, Minn.	Dean of the Graduate School and Professor of Mathematics and Mechanics, College of Engineering, University of Minnesota	1893
Eddy, Horace T. 109 West Third St., Cincinnati, Ohio.	Machinery Sales Company	1903
Edmands, S. Sumner Brooklyn, N. Y.	Head of Department of Applied Electricity, Pratt Institute	1903
Egbert, Hermas V. State College, Pa.	Instructor in Mechanics and Materials of Construction, The Pennsylvania State College	1907
Elliott, James W. 41 South Prospect St., Burlington, Vt.	Assistant Professor of Civil Engineering, University of Vermont	1908
Emory, Frederick L. Morgantown, W. Va.	Professor of Mechanics and Applied Mathematics, West Virginia University	1894
Enders, Henry C. New York, N. Y.	Assistant Professor of Chemistry, Cooper Union for the Advancement of Science	1908
Endsley, Louis E. 815 North 9th St., Lafayette, Ind.	Associate Professor of Railway Mechanical Engineering, Purdue University	1907
Enger, Melvin L. 611 West Illinois St., Urbana, Ill.	Instructor in Theoretical and Applied Mechanics, University of Illinois	1907
Engler, Edmund A. Worcester, Mass.	President of Worcester Polytechnic Institute	1907
Ennis, William D. Brooklyn, N. Y.	Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn	1907
Eno, Frank H. 48 Smith Place, Columbus, Ohio.	Professor of Municipal Engineering, Ohio State University	1907

Name and Address.	Title.	Date of Membership.
Esterline, J. Walter..... 145 Andrew Place, West Lafayette, Ind.	Associate Professor of Electrical Engineering, Purdue University.......	1903
Esty, William .... South Bethlehem, Pa.	Professor of Electrical Engineering, Lehigh University	1898
Evans, Frederick H....... 103 Ayres Ave., Peoria, Ill.	Instructor in Manual Arts, Bradley Polytechnic Institute......	1907
Evans, Henry B.......... College Hall, Philadelphia, Pa.	Assistant Professor of Mathematics, University of Pennsylvania........	1908
Evans, Herbert S......... Boulder, Colo.	Professor of Electrical Engineering, University of Colorado............	1905
Faig, John T............. 254 Greendale Ave., Clifton, Cincinnati, O.	Professor of Mechanical Engineering, University of Cincinnati...........	1899
Fairfield, Howard P...... 25 John St., Worcester, Mass.	Instructor in Shop Engineering, Worcester Polytechnic Institute....	1907
Farnham, Charles S...... 671 W. Divinity Hall, New Haven, Conn.	Instructor in Civil Engineering, Sheffield Scientific School of Yale University	1908
Farwell, Elmer S........ 309 Broadway, New York, N. Y.	Consulting Engineer	1895
Ferguson, Olin J......... 244 Parkwood Boulevard, Schenectady, N. Y.	Assistant Professor of Electrical Engineering, Union College...........	1908
Fermier, Emile J......... College Station, Texas.	Professor of Mechanical Engineering, Texas Agricultural and Mechanical College	1903
Fernald, Robert H........ Cleveland, Ohio.	Professor of Mechanical Engineering, Case School of Applied Science.....	1899
Fish, Fred A............. Ames, Iowa.	Professor of Electrical Engineering, Iowa State College................	1905
Fisher, James, Jr......... Houghton, Mich.	Professor of Mathematics and Physics, Michigan College of Mines.........	1899
Flather, John J.......... Minneapolis, Minn.	Professor of Mechanical Engineering, University of Minnesota...........	1893
Fletcher, Robert .... Hanover, N. H.	Professor of Civil Engineering, Director of Thayer School of Civil Engineering, Dartmouth College....	1894

Name and Address.	Title.	Date of Membership.
Focke, Theodore M. 2057 Cornell Road, Cleveland, Ohio.	Kerr Professor of Mathematics, Case School of Applied Science	1907
Fogg, Benjamin G. State College, Pa.	Instructor in Civil Engineering, The Pennsylvania State College	1907
Ford, Arthur H. Iowa City, Iowa.	Professor of Electrical Engineering, State University of Iowa	1903
Ford, Howard Carlton Ames, Iowa.	Assistant Professor of Irrigation Engineering and Surveying, Iowa State College	1907
Foss, Fred E. Pittsburg, Pa.	Professor of Civil Engineering Practice, Carnegie Technical Schools	1893
Fowler, Charles E. 737 New York Block, Seattle, Wash.	President of International Contract Company, and Lecturer, University of Washington	1903
Fowler, Sterling DeWitt. State College, Pa.	Associate Professor of Heat Engineering, The Pennsylvania State College.	1907
Frankforter, George B. Minneapolis, Minn.	Professor of Chemistry, University of Minnesota	1897
Franklin, William S. Bethlehem, Pa.	Professor of Physics, Lehigh University	1900
Frary, Hobart D. 3108 Garfield Ave., So., Minneapolis, Minn.	Instructor in Engineering Mathematics, University of Minnesota	1908
Freedman, William H. 100 South Union St., Burlington, Vt.	Professor of Electrical Engineering, University of Vermont	1902
Freeman, Clarence E. Chicago, Ill.	Director of Electrical Engineering Department, Armour Institute of Technology	1904
French, Arthur W. Worcester, Mass.	Professor of Civil Engineering, Worcester Polytechnic Institute	1900
French, Thomas E. Columbus, Ohio.	Professor of Engineering Drawing, Ohio State University	1899
Frink, Fred G. Eugene, Ore.	Professor of Railway Engineering, University of Oregon	1902
Frost, Albert E. 4527 Winthrop St., Pittsburg, Pa.	Acting Dean and Professor of Mathematics, Western University of Pennsylvania	1908
Frost, G. Harwood 220 Broadway, New York, N. Y.	Editor and Manager, *The Engineering Digest;* Manager, Book Department, *Engineering News*	1907

Name and Address.	Title.	Date of Membership.
Fuller, Almon H. University Station, Seattle, Wash.	Professor of Civil Engineering and Dean of the College of Engineering, University of Washington	1901
Fuller, Charles E. Wellesley, Mass.	Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology	1907
Furman, Franklin DeR. 700 Hudson St., Hoboken, N. J.	Professor of Kinematics and Machine Design, Stevens Institute of Technology	1907
Galbraith, John Toronto, Ontario.	Professor of Engineering and Dean of the Faculty of Applied Science, University of Toronto	1893
Ganz, Albert F. Hoboken, N. J.	Professor of Electrical Engineering, Stevens Institute of Technology	1903
Garman, Harry O. 739 Owen St., Lafayette, Ind.	Associate Professor of Civil Engineering, Purdue University	1907
Garrison, Wilbert A. 99 Van Vranken Ave., Schenectady, N. Y.	Assistant Professor of Mathematics, Engineering School of Union College.	1908
Gavett, George Irving 5601 University Boulevard, Seattle, Wash.	Instructor in Mathematics, University of Washington	1907
Gay, Robert W. 229 West Mulberry St., Fort Collins, Colo.	Associate Professor of Civil Engineering, Colorado State Agricultural College	1907
Gehring, Herbert A. 195 North Allen St., Albany, N. Y.	Assistant Engineer New York State Barge Canal Office	1907
George, Nathan R., Jr. Boston, Mass.	Assistant Professor of Mathematics, Massachusetts Institute of Technology	1907
Gibbons, Charles B. Albuquerque, N. Mex.	Professor of Mechanical Engineering, University of New Mexico	1908
Giesecke, F. E. Berliner Strasse 46, Charlottenburg, Germany.	Professor of Drawing, Texas Agricultural and Mechanical College	1893
Gill, James H. Urbana, Ill.	Assistant Professor of Machine Construction, University of Illinois	1896
Gillespie, Peter 63 Alexander St., Toronto, Ontario.	Lecturer on Theory of Construction, University of Toronto	1905

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
GILLETTE, HALBERT P. Park Row Building, New York, N. Y.	Consulting Engineer	1905
GLADSON, WILLIAM N. Fayetteville, Ark.	Professor of Electrical Engineering, University of Arkansas	1903
GOETZE, FREDERICK A. New York, N. Y.	Dean of the Schools of Mines, Engineering and Chemistry, Columbia University	1906
GOODENOUGH, GEORGE A. Urbana, Ill.	Associate Professor of Mechanical Engineering, University of Illinois	1900
GOSS, WILLIAM F. M. Urbana, Ill.	Dean of the College of Engineering, University of Illinois	1893
GRANT, ELMER D. Houghton, Mich.	Assistant Professor of Mathematics and Physics, Michigan College of Mines	1905
*GRAY, THOMAS Terre Haute, Ind.	Professor of Dynamic Engineering, Rose Polytechnic Institute	1895
GREEN, BERNARD R. 1738 N St., Washington, D. C.	Superintendent of Buildings and Grounds, Library of Congress	1906
GREEN, JAMES A. Alberta, Lincoln Co., Idaho.	Chief Engineer, Tri-State Land Co.	1904
GREENE, ARTHUR M., JR. Troy, N. Y.	Professor of Mechanical Engineering, Rensselaer Polytechnic Institute	1903
GREGORY, WILLIAM B. 630 Pine St., New Orleans, La.	Professor of Experimental Engineering, The Tulane University of Louisiana; and Irrigation Engineer U. S. Department of Agriculture	1907
GROAT, BENJAMIN F. Minneapolis, Minn.	Professor of Mechanics and Mathematics, School of Mines, University of Minnesota	1899
GROVER, NATHAN C. 80 North 19th St., East Orange, N. J.	Assistant Hydraulic Engineer, J. G. White & Co., 43 Exchange Place, New York, N. Y.	1894
GUNTHER, CHARLES O. Hoboken, N. J.	Professor of Mathematics, Stevens Institute of Technology	1907
HALSEY, FREDERICK A. 505 Pearl St., New York, N. Y.	Editor-in-Chief, *American Machinist*, Hill Publishing Company	1907
HAMERSCHLAG, ARTHUR A. Pittsburg, Pa.	Director, Carnegie Technical Schools	1903

---

* Deceased December 19, 1908.

Name and Address.	Title.	Date of Membership.
Hancock, Edward L. Lafayette, Ind.	Assistant Professor of Applied Mechanics, Purdue University	1903
Harding, C. Francis 111 Fowler Ave., Lafayette, Ind.	Professor of Electrical Engineering and Director Electrical Laboratory, Purdue University	1908
Haring, Alexander New York, N. Y.	Professor of Bridge and Railway Engineering, New York University	1907
Harrington, John Lyle 608 New Nelson Bldg., Kansas City, Mo.	Consulting Engineer, Waddell & Harrington	1903
Harris, Abram W. Evanston and Chicago, Ill.	President, Northwestern University	1897
Harris, Elmo G. Rolla, Mo.	Professor of Civil Engineering, School of Mines and Metallurgy, University of Missouri	1894
Harter, George A. Newark, Del.	President of Delaware College	1908
Hartmann, Francis M. New York, N. Y.	Professor of Physics, Electrical and Mechanical Engineering, Cooper Union for the Advancement of Science	1908
Haskell, Eugene E. Ithaca, N. Y.	Director, College of Civil Engineering, Cornell University	1907
Hastings, Hudson B. 69 Federal St., Brunswick, Me.	Assistant Professor in charge of Surveying and Drawing, Bowdoin College	1908
Hatt, William K. Lafayette, Ind.	Professor of Civil Engineering, Purdue University	1895
Haupt, Lewis M. 107 North 35th St., Philadelphia, Pa.	Consulting Engineer	1907
Haviland, Edwin, Jr. 4703 Brooklyn Ave., Seattle, Wash.	University of Washington	1902
Hawes, Joseph H. Dorchester Center, Mass.	Teacher of Manual Training and Mechanical Drawing, Dorchester High School, Boston	1900
Hayford, John F. Washington, D. C.	Inspector of Geodetic Work and Chief of Computing Division, Coast and Geodetic Survey	1905

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
HAYNES, ARTHUR E. Minneapolis, Minn.	Professor of Engineering Mathematics, University of Minnesota	1895
HAYWARD, HARRISON W. Boston, Mass.	Assistant Professor of Applied Mechanics, Massachusetts Institute of Technology	1904
HAZEN, JOHN V. Hanover, N. H.	Professor of Civil Engineering, Dartmouth College	1896
HAZLETON, WILLIAM S. 802 Monroe St., Ann Arbor, Mich.	Assistant Professor of Mechanical Engineering, University of Michigan	1907
HECK, ROBERT C. H. 192 College Ave., New Brunswick, N. J.	Professor of Mechanical Engineering, Rutgers College	1907
HEDRICK, IRA G. Kansas City, Mo.	Consulting Engineer, Keith and Perry Building	1894
HENLEY, WILLIAM W. Tucson, Ariz.	Professor of Mechanic Arts, University of Arizona	1907
HERGET, ALBERT M. 107 Boyd Ave., Baton Rouge, La.	Professor of Drawing and Mechanic Arts, Louisiana State University	1903
HIBBARD, ANGUS S. 203 Washington St., Chicago, Ill.	2d Vice-President and General Manager, Chicago Telephone Company	1907
HIBBARD, H. WADE Columbia, Mo.	Professor of Mechanical Engineering, University of Missouri	1896
HIGBEE, FRED. GOODSEN Iowa City, Iowa.	Assistant Professor, and Head of the Department of Drawing and Descriptive Geometry, State University of Iowa	1906
HILL, JOHN E. Providence, R. I.	Professor of Civil Engineering, Brown University	1894
HITCHCOCK, EMBURY A. Columbus, Ohio.	Professor of Experimental Engineering, Ohio State University	1899
HOAD, WILLIAM CHRISTIAN. Lawrence, Kan.	Associate Professor of Civil Engineering, University of Kansas	1907
HODGKINS, HOWARD L. 1830 T Street, Washington, D. C.	Dean, Washington College of Engineering, George Washington University	1908
HOFFMAN, ARTHUR H. 510 Clark Ave., Ames, Iowa.	Assistant Professor of Physics, Iowa State College of Agriculture and Mechanic Arts	1907

Name and Address.	Title.	Date of Membership.
Hoffman, James D. 301 State St., West Lafayette, Ind.	Professor of Engineering Design, Purdue University	1907
Hofman, Heinrich O. Boston, Mass.	Professor of Metallurgy, Massachusetts Institute of Technology	1894
Holden, Charles A. Hanover, N. H.	Professor of Civil Engineering, Thayer School of Civil Engineering, Dartmouth College	1901
Hollis, Ira N. Cambridge, Mass.	Professor of Engineering, Harvard University	1894
Holmes, Joseph A. Washington, D. C.	Expert in charge, Technologic Branch United States Geological Survey	1907
Hood, Ozni P. Houghton, Mich.	Professor of Mechanical and Electrical Engineering, Michigan College of Mines	1893
Hooper, William L. 124 Professor's Row, Tufts College, Mass.	Professor of Electrical Engineering, Tufts College	1907
Hormell, Wm. Garfield 268 N. Sandusky St., Delaware, Ohio.	Professor of Physics, Ohio Wesleyan University	1907
Horton, George T. Throop and 105th Sts., Chicago, Ill.	Vice-President of Chicago Bridge and Iron Co.	1903
Hoskins, Leander M. Stanford University, Cal.	Professor of Applied Mathematics, Leland Stanford Junior University	1893
Houghton, Charles E. New York, N. Y.	Associate Professor Mechanical Engineering, New York University	1908
Hovda, Olaf Minneapolis, Minn.	Instructor in Engineering Mathematics, University of Minnesota	1908
Howard, John W. 465 Washington St., Brookline, Mass.	Instructor in Civil Engineering, Massachusetts Institute of Technology	1907
Howe, Charles S. Cleveland, Ohio.	President of Case School of Applied Science	1902
Howe, Malverd A. Terre Haute, Ind.	Professor of Civil Engineering, Rose Polytechnic Institute	1894
Hubbard, Albert K. 1227 Ohio St., Lawrence, Kan.	Assistant Professor of Civil Engineering, University of Kansas	1907

Name and Address.	Title.	Date of Membership.
Hughes, Hector J. 114 Pierce Hall, Cambridge, Mass.	Assistant Professor of Civil Engineering, Harvard University	1907
Hughes, John W. 775 Hattie St., Schenectady, N. Y.	Assistant Professor of Civil Engineering, Union University	1907
Hume, Alfred University, Miss.	Vice-Chancellor and Professor of Mathematics, University of Mississippi	1894
Humphreys, Alexander C. Hoboken, N. J.	President of Stevens Institute of Technology	1903
Humphreys, David C. Lexington, Va.	Dean of the School of Engineering and Professor of Civil Engineering, Washington and Lee University	1893
Hunt, John H. Columbus, Ohio.	Associate Professor Electrical Engineering, Ohio State University	1908
Hunter, John A. Boulder, Colo.	Professor of Mechanical Engineering, University of Colorado	1904
Huntington, Edward V. 35 Fairfax Hall, Cambridge, Mass.	Assistant Professor of Mathematics, Harvard University	1906
Huntoon, Louis D. 284 Orange St., New Haven, Conn.	Professor of Mining and Metallurgy, Sheffield Scientific School, Yale University	1908
Hutton, Sol. E. 106 Polk St., Moscow, Idaho.	Assistant in Mechanical and Electrical Engineering, University of Idaho	1907
Hyde, A. Lincoln Columbia Club, Columbia, Mo.	Assistant Professor of Bridge Engineering, University of Missouri	1904
Ingram, Edward L. Philadelphia, Pa.	Assistant Professor of Railroad Engineering and Geodesy, University of Pennsylvania	1908
Ives, Howard C. Worcester, Mass.	Assistant Professor of Railroad Engineering, Worcester Polytechnic Institute	1901
Jackson, Dugald C. Boston, Mass.	Professor of Electrical Engineering, Massachusetts Institute of Technology	1893
Jackson, John Price State College, Pa.	Dean of School of Engineering, The Pennsylvania State College	1894

Name and Address.	Title.	Date of Membership.
Jacobus, D. S. 85 Liberty St., New York, N. Y.	Advisory Engineer, The Babcock & Wilcox Company	1893
Jacoby, Henry S. Ithaca, N. Y.	Professor of Bridge Engineering, Cornell University	1894
James, Walter H. Boston, Mass.	Instructor in Mechanical Engineering, Massachusetts Institute of Technology	1904
Jameson, Joseph M. Brooklyn, N. Y.	Head of Department of Physics, Pratt Institute	1903
Jenkins, A. Lewis 2348 Ohio Ave., Cincinnati, Ohio.	Assistant Professor of Mechanical Engineering, University of Cincinnati	1907
Jenkins, David Rhys 815 Spruce St., Boulder, Colo.	Instructor in Electrical Engineering, University of Colorado	1906
Jenson, Joseph Logan, Utah.	Consulting Engineer, Office of State Engineer, Salt Lake City	1903
Jewett, Arthur C. Orono, Maine.	Professor of Mechanical Engineering, University of Maine	1907
Johnson, John S. A. Blacksburg, Va.	Professor of Experimental Engineering, Virginia Polytechnic Institute	1907
Johnson, John W. Lock Box 40, University, Miss.	Professor of Physics, University of Mississippi	1907
Johnson, Lewis J. Cambridge, Mass.	Professor of Civil Engineering, Harvard University	1898
Johnston, William A. Hillside Terrace, Belmont, Mass.	Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology	1907
Jones, Bassett, Jr. 1 Madison Ave., New York, N. Y.	Consulting Engineer	1904
Jones, Clement R. Morgantown, W. Va.	Professor of Mechanical Engineering, West Virginia University	1895
Jones, Forrest R. 1702 Melrose Ave., Knoxville, Tenn.		1893
Jones, Frederick S. Minneapolis, Minn.	Professor of Physics and Dean of College of Engineering, University of Minnesota	1903

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
JUDD, HORACE 245 West 4th Ave., Columbus, Ohio.	Assistant Professor of Experimental Engineering, Ohio State University	1907
KAUP, WILLIAM J. Brooklyn, N. Y.	Head Instructor in Machine Work, Pratt Institute	1903
KAVANAUGH, WILLIAM H. Minneapolis, Minn.	Professor of Experimental Engineering, University of Minnesota	1902
KAY, EDGAR B. University, Ala.	Dean, Department of Engineering; Professor of Civil Engineering, University of Alabama	1898
KELLY, WILLIAM Vulcan, Mich.	General Manager Penn Iron Mining Company, and Chairman Board of Control, Michigan College of Mines.	1905
KENERSON, WILLIAM H. 100 Morris Ave., Providence, R. I.	Associate Professor of Mechanical Engineering, Brown University	1903
KENNEDY, FRANK LOWELL 43 Appleton St., Cambridge, Mass.	Assistant Professor of Drawing and Machine Design, Harvard University.	1904
KENT, JAMES M. Kansas City, Mo.	Instructor in Steam and Electricity, Manual Training High School of Kansas City	1903
KENT, WILLIAM Sandusky, Ohio.	General Manager of The Sandusky Foundry and Machine Company	1894
KENYON, ALFRED M. 315 University St., West Lafayette, Ind.	Professor of Mathematics, Purdue University	1908
KERR, CHARLES V. Wellsville, N. Y.	Chief Engineer, Kerr Turbine Co.	1902
KETCHUM, MILO S. Boulder, Colo.	Dean of the College of Engineering and Professor of Civil Engineering, University of Colorado	1903
KING, ROY S. 43 Wroe Ave., Dayton, Ohio.	General Superintendent, Hall-Cronan Co.	1904
KINGSBURY, ALBERT East Pittsburg, Pa.	Mechanical Engineer with Westinghouse Electrical and Manufacturing Co.	1893

Name and Address.	Title.	Date of Membership.
Kinsley, Carl 5454 Greenwood Ave., Chicago, Ill.	Assistant Professor of Physics, University of Chicago	1903
Kirchhoff, Charles 422 West End Ave., New York, N. Y.	General Manager and Vice-President, David Williams Company, Publishers	1907
Klein, Arthur W. 158 South New St., Bethlehem, Pa.	Instructor in Mechanical Engineering, Lehigh University	1908
Knight, Carl D. 194 Park Ave., Worcester, Mass.	Instructor in Experimental Electrical Engineering, Worcester Polytechnic Institute	1907
Knight, William A. 206 West Lane Ave., Columbus, Ohio.	Assistant Professor of Machine Shop Practice, Ohio State University	1907
Knipp, Charles T. 913 West Nevada St., Urbana, Ill.	Assistant Professor of Physics, University of Illinois	1907
Knoch, Julius J. Fayetteville, Ark.	Professor of Civil Engineering, University of Arkansas	1898
Koch, Ernest H., Jr. 421 Park Place, Brooklyn, N. Y.	Instructor in Mathematics, Pratt Institute	1904
Kortright, Frederic L. 234 Jackson Ave., Morgantown, W. Va.	Professor of Chemistry, West Virginia University	1907
Kunze, Edward J. Brooklyn, N. Y.	Instructor in Physics, Pratt Institute	1907
Kyser, Henry H. Talladega, Ala.	Electrical Engineer	1897
Ladd, George E. Wilburton, Okla.	President, Oklahoma School of Mines and Metallurgy	1901
Lambert, Byron J. 215 Fairchild St., Iowa City, Ia.	Professor of Structural Engineering, State University of Iowa	1907
Lambert, Preston A. 215 South Center St., Bethlehem, Pa.	Professor of Mathematics, Lehigh University	1897
Landreth, Olin H. Schenectady, N. Y.	Professor of Civil Engineering, Union University	1893

Name and Address.	Title.	Date of Membership.
Lane, Henry M. 1924 Prospect Ave., Cleveland, Ohio.	Editor, *Castings* and *Wood Craft*	1900
Langsdorf, Alexander S. St. Louis, Mo.	Professor of Electrical Engineering, Washington University	1903
Lanza, Gaetano Boston, Mass.	Professor of Applied Mechanics, in charge of the Department of Mechanical Engineering, Massachusetts Institute of Technology	1893
Lawrance, Charles H. 321 University St., West Lafayette, Ind.	Instructor in Mechanics, Purdue University	1906
Lawrence, James W. Fort Collins, Colo.	Professor of Mechanical Engineering, State Agricultural College	1898
Lawrence, Ralph R. 34 Sumner St., Dorchester, Mass.	Associate Professor of Electrical Engineering, Massachusetts Institute of Technology	1907
Lawrence, William H. 34 Sumner St., Dorchester, Mass.	Associate Professor of Architecture, Massachusetts Institute of Technology	1907
Leeds, Charles C. 5508 Elmer St., Pittsburg, Pa.	Head of Department of Drawing, School for Apprentices and Journeymen, Carnegie Technical Schools	1907
Leete, John H. Pittsburg, Pa.	Dean of the School of Applied Science, Carnegie Technical Schools	1907
LePage, Clifford B. P. O. Box 526, Stamford, Conn.	Instructor in Physics, Stevens Institute of Technology	1908
Leutwiler, Oscar Adolph 511 West Green St., Urbana, Ill.	Assistant Professor of Machine Design, University of Illinois	1906
Lindemann, Charles A. Lewisburg, Pa.	Professor of Applied Mathematics, Bucknell University	1905
Linville, Clarence P. State College, Pa.	Assistant Professor of Metallurgy, School of Mines and Metallurgy, The Pennsylvania State College	1904
Little, Charles N. 818 Elm St., Moscow, Idaho.	Professor of Civil Engineering, University of Idaho	1907
Lockwood, Edwin H. 52 Division St., New Haven, Conn.	Assistant Professor of Mechanical Engineering, Sheffield Scientific School, Yale University	1908

Name and Address.	Title.	Date of Membership.
Lodge, W. Lloyd Box 106, East Lansing, Mich.	Senior Instructor in Physics, Michigan State Agricultural College.	1908
Longyear, John M. Marquette, Mich.	Member Board of Control, Michigan College of Mines	1904
Lord, Nathaniel W. 338 West 8th Ave., Columbus, Ohio.	Professor of Metallurgy and Mineralogy and Director of the School of Mines, Ohio State University	1907
Lory, Charles A. 903 Stover St., Fort Collins, Colo.	Professor of Physics and Electrical Engineering, State Agricultural College of Colorado	1908
Loughlin, Gerald Francis 45 Hosmer St., Everett, Mass.	Instructor in Geology, Massachusetts Institute of Technology	1907
Love, A. Cavitt Beaumont, Texas.	Construction Engineer, Beaumont Irrigating Company	1900
Lucke, Charles Edward New York, N. Y.	Professor of Mechanical Engineering, Columbia University	1906
Ludy, Llewellyn V. 229 University St., West Lafayette, Ind.	Professor of Mechanical Engineering, Purdue University	1903
Lundgren, E. L. Manila, P. I.	Assistant Engineer, Bureau of Public Works	1907
Lyman, Richard R. 1084 Third Ave., Salt Lake City, Utah.	Professor of Civil Engineering, University of Utah	1908
McCaustland, Elmer J. 5043 15th Ave., N. E., Seattle, Wash.	Professor of Civil Engineering, University of Washington	1902
McCormick, Edmund B. 400 Humboldt St., Manhattan, Kan.	Professor of Mechanical Engineering and Superintendent of Shops, Kansas State Agricultural College	1908
McDaniel, Allen B. Vermilion, S. Dak.	Professor of Civil Engineering, University of South Dakota, and Consulting Civil Engineer and Architect	1907
McKibben, Frank P. South Bethlehem, Pa.	Professor of Civil Engineering, Lehigh University	1904
McNair, Fred W. Houghton, Mich.	President, Michigan College of Mines	1897
McNown, William C. 774 National Ave., Richmond, Ind.	Professor of Civil Engineering, Earlham College	1907

Name and Address.	Title.	Date of Membership.
McRae, Austin Lee 1202 State St., Rolla, Mo.	Professor of Physics, School of Mines and Metallurgy, University of Missouri	1907
MacNaughton, James Calumet, Mich.	General Manager, Calumet and Hecla Mines, and Member Board of Control, Michigan College of Mines	1905
Mabery, Charles F. 1949 East 107th St., Cleveland, Ohio.	Professor of Chemistry, Case School of Applied Science	1907
Mack, John G. D. 110 East Johnson St., Madison, Wis.	Professor of Machine Design, College of Engineering, University of Wisconsin	1901
Macomber, George S. Ithaca, N. Y.	Assistant Professor of Electrical Engineering, Sibley College, Cornell University	1904
Magnusson, C. Edward University Station, Seattle, Wash.	Professor of Electrical Engineering, University of Washington	1907
Magruder, William T. Columbus, Ohio.	Professor of Mechanical Engineering, Ohio State University	1893
Maitland, Alexander, Jr. Kansas City, Mo.	President of Kansas City Bridge Co.	1903
Malcolm, Charles W. 1001 West Illinois St., Urbana, Ill.	Assistant Professor of Structural Engineering, University of Illinois	1907
Marburg, Edgar Philadelphia, Pa.	Professor of Civil Engineering, University of Pennsylvania	1894
Marston, Anson Ames, Iowa.	Dean of the Division of Engineering and Professor of Civil Engineering, Iowa State College	1894
Martenis, John Van S. Minneapolis, Minn.	Assistant Professor in Mechanical Engineering, University of Minnesota	1908
Martin, Louis A., Jr. 824 Bloomfield St., Hoboken, N. J.	Professor of Mechanics, Stevens Institute of Technology	1907
Marvin, Frank O. Lawrence, Kan.	Dean of the School of Engineering and Professor of Civil Engineering, University of Kansas	1893
Marx, Charles D. Stanford University, Cal.	Professor of Civil Engineering, Leland Stanford Junior University	1893

Name and Address.	Title.	Date of Membership.
Mathews, Hubert B. Brookings, S. Dak.	Professor of Physics and Electrical Engineering, South Dakota Agricultural College	1896
Matthews, Robert Clayton Knoxville, Tenn.	Secretary, Tau Beta Pi Association and Assistant Professor Drawing and Machine Design, University of Tennessee	1908
Maurer, Edward R. Madison, Wis.	Professor of Mechanics, University of Wisconsin	1897
Maxwell, M. C. Brooklyn, N. Y.	Head Instructor in Applied Mechanics, Pratt Institute	1908
Mead, Daniel W. 1015 University Ave., Madison, Wis.	Professor of Hydraulic and Sanitary Engineering, University of Wisconsin	1908
Mead, Elwood Melbourne, Australia.	Chairman, State Rivers and Water Supply Commission, Treasury Gardens	1901
Meeker, Warren H. Ames, Iowa.	Professor of Mechanical Engineering, Iowa State College	1903
Mees, C. Leo Terre Haute, Ind.	President, Rose Polytechnic Institute.	1894
Mendenhall, Thomas C. No. 3 via Palestro, Florence, Italy.	Mail to Worcester Polytechnic Institute, Worcester, Mass. Care of Mr. Marshall	1895
Merrill, Allyne L. Hillside Terrace, Belmont, Mass.	Professor of Mechanism and Secretary of the Faculty, Massachusetts Institute of Technology	1907
Merrill, Joseph F. Salt Lake City, Utah.	Director, Utah State School of Mines, Professor of Physics and Electrical Engineering, University of Utah	1907
Merriman, Mansfield 32 West 40th St., New York, N. Y.	Consulting Engineer	1893
Miggett, William L. 712 S. Thayer St., Ann Arbor, Mich.	Superintendent of the Engineering Shops, University of Michigan	1902
Millar, Adam V. 222 Charter St., Madison, Wis.	Assistant Professor of Mechanical Drawing, University of Wisconsin	1904
Miller, Dayton C. Cleveland, Ohio.	Professor of Physics, Case School of Applied Science	1907

Name and Address.	Title.	Date of Membership.
Miller, William A....... 508 South 5th St., Columbia, Mo.	Assistant Professor of Railway Engineering, University of State of Missouri	1908
Mitcham, George Nathan. Auburn, Ala.	Professor of Civil Engineering, Alabama Polytechnic Institute.....	1906
Modjeski, Ralph .... 5041 Washington Ave., Chicago, Ill.	Consulting Engineer	1908
Molitor, David A......... Ithaca, N. Y.	Professor of Topographic and Geodetic Engineering, College of Civil Engineering, Cornell University.........	1907
Monin, Louis C........... Chicago, Ill.	Dean of the Cultural Studies and Professor of Economics and Philosophy, Armour Institute of Technology....	1904
Moore, Herbert F......... Champaign, Ill.	Assistant Professor of Theoretical and Applied Mechanics, University of Illinois	1905
Moore, Lewis E........... 85 Washington Park, Newtonville, Mass.	Assistant Professor of Civil Engineering, Massachusetts Institute of Technology	1907
Moore, Stanley H........ St. Louis, Mo.	Director, Mechanic Arts, McKinley High School	1902
More, Charles C.......... University Station, Seattle, Wash.	Associate Professor of Civil Engineering, University of Washington......	1901
Morecroft, J. Harold.... 122 St. James Place, Brooklyn, N. Y.	Instructor in Applied Electricity, Pratt Institute	1908
Moreton, David Penn..... 426 34th St., Chicago, Ill.	Assistant Professor of Electrical Engineering, Armour Institute of Technology	1907
Morley, Fred .... Lapeer, Mich.	Res. Engr. St. Clair Flats Survey for the State of Michigan.............	1896
Morris, Clyde T.......... 292 East 16th Ave., Columbus, Ohio.	Professor of Structural Engineering, Ohio State University.............	1907
Morrison, Charles E..... New York, N. Y.	Tutor, Department of Civil Engineering, Columbia University..........	1907
Morse, George H.......... 350 North 28th St., Lincoln, Neb.	Professor of Electrical Engineering, University of Nebraska............	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
MOSELEY, ALEXANDER W. 798 Monroe St., Chicago, Ill.	Professor of Mechanics, Head of Department of Engineering, Lewis Institute	1907
MOTT, WILLIAM E. 174 Harvard St., Brookline, Mass.	Associate Professor of Hydraulic Engineering, Massachusetts Institute of Technology	1907
MOYER, JAMES AMBROSE Ann Arbor, Mich.	Assistant Professor of Mechanical Engineering, in charge of Mechanical Laboratories, University of Michigan	1904
MUNROE, GEORGE E. Box 351, State College, Pa.	Instructor in Electrical Engineering, The Pennsylvania State College	1907
MUNROE, HENRY S. New York, N. Y.	Professor of Mining, School of Mines, Columbia University	1893
MUNROE, JAMES P. 79 Summer St., Boston, Mass.	Treasurer, Munroe Felt and Paper Co., Secretary of Corporation of Massachusetts Institute of Technology	1904
MYERS, RALPH E. State College, Pa.	Assistant Professor of Electro-chemical Engineering, The Pennsylvania State College	1907
NAGLE, JAMES C. College Station, Tex.	Professor of Civil Engineering, Agricultural and Mechanical College of Texas	1897
NEFF, FRANK H. Cleveland, Ohio.	Professor of Civil Engineering, Case School of Applied Science	1895
NESBIT, ARTHUR F. Durham, N. H.	Professor of Physics and Electrical Engineering, New Hampshire College of Agriculture and Mechanic Arts	1902
NEWKIRK, BURT L. 1016 29th Ave., N. E., Minneapolis, Minn.	Assistant Professor of Mathematics and Mechanics, College of Engineering, University of Minnesota	1908
NEWTON, JAMES DYNAN 1320 Massachusetts St., Lawrence, Kan.	Assistant Professor of Civil Engineering, University of Kansas	1908
NICHOLS, GEN. EDWARD W. Lexington, Va.	Superintendent, Virginia Military Institute	1908
NOBLE, HENRY P. 912 Forest Ave., Ann Arbor, Mich.	Instructor in Machine Design and Assistant to Superintendent of Shops, University of Michigan	1908
NORRIS, EARLE B. 301 Johnson Court, Madison, Wis.	Assistant Professor of Mechanical Engineering, Extension Division, University of Wisconsin	1907

Name and Address.	Title.	Date of Membership.
Norris, Henry H. Ithaca, N. Y.	Professor of Electrical Engineering, Cornell University	1900
North, Herbert B. 250 Whaley Ave., New Haven, Conn.	Instructor of Machine Design and Descriptive Geometry, Sheffield Scientific School, Yale University	1908
Norton, Charles L. 12 Union St., Manchester-by-the-Sea, Mass.	Associate Professor of Physics, Massachusetts Institute of Technology	1908
Norwood, Charles Joseph. 339 Aylesford Place, Lexington, Ky.	Dean, School of Mining Engineering, State University of Kentucky	1907
Noyes, Arthur A. Boston, Mass.	Acting President of Massachusetss Institute of Technology	1907
Nunn, Paul N. Provo, Nev.	Chief Engineer, The Telluride Power Co., and Consulting Engineer	1907
O'Byrne, J. F. Dahlonega, Ga.	Professor of Mining and Electrical Engineering, N. G. A. College	1905
Ohle, Ernest L. St. Louis, Mo.	Professor of Mechanical Engineering, Washington University	1905
Olsen, Tinius 500 North 12th St., Philadelphia, Pa.	Mechanical Engineer	1907
Orton, Edward, Jr. Columbus, Ohio.	Professor of Ceramic Engineering, Ohio State University	1900
Osborn, Frederick A. 5215 15th Ave., N. E., Seattle, Wash.	Professor of Physics, University of Washington	1907
Ostrander, John E. Amherst, Mass.	Professor of Mathematics and Civil Engineering, Massachusetts Agricultural College	1894
Ostrup, John C. 203 West 103d St., New York, N. Y.	Professor of Structural Engineering, Stevens Institute of Technology	1907
Owens, Robert B. Montreal, Quebec.	Professor of Electrical Engineering, McGill University	1894
Palmer, Thomas W. Montevallo, Ala.	President of the Alabama Girls' Industrial School	1905
Palmer, Walter K. 718 Dwight Building, Kansas City, Mo.	Consulting Mechanical and Electrical Engineer	1899

Name and Address.	Title.	Date of Membership.
Park, Charles F. 62 Summer St., Taunton, Mass.	Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology	1903
Parker, Lawrence G. 705 S. 6th St., Champaign, Ill.	Associate (in Civil Engineering), University of Illinois	1907
Parsons, Floyd W. 505 Pearl St., New York, N. Y.	Associate Editor, *Engineering and Mining Journal*	1905
Patterson, Andrew H. Chapel Hill, N. C.	Professor of Physics, University of North Carolina	1907
Paul, Charles E. Chicago, Ill.	Associate Professor of Mechanics, Armour Institute of Technology	1907
Pence, William D. Madison, Wis.	Professor of Railway Engineering, University of Wisconsin	1895
Perry, Charles Frederick 3416 Cedar St., Milwaukee, Wis.	Director, Milwaukee School of Trades	1907
Pettee, Charles H. Durham, N. H.	Professor of Mathematics, New Hampshire College	1898
Phelon, Joseph O. 27 Schussler Road, Worcester, Mass.	Professor of Electrical Engineering, Worcester Polytechnic Institute	1902
Phetteplace, Thurston M. 1612 Broad St., Providence, R. I.	Assistant Professor of Mechanical Engineering, Brown University	1903
Phillips, James D. Madison, Wis.	Professor of Drawing, University of Wisconsin	1899
Pierce Charles H. Converse Hall, Burlington, Vt.	Assistant Professor of Railroad Engineering and Mechanics, University of Vermont	1906
Plumb, Hylon T. 318 Waldron St., Lafayette, Ind.	Associate Professor of Electrical Engineering, Purdue University	1907
Polson, Joseph A. Box 166, East Lansing, Mich.	Instructor in Mechanical Engineering, Michigan Agricultural College	1907
Poole, Cecil P. 36 West End Road, South Orange, N. J.	Editor, *Power*	1907
Poorman, Alfred P. 1133 Pleasant St., Boulder, Colo.	Instructor in Civil Engineering, University of Colorado	1907

Name and Address.	Title.	Date of Membership.
Porter, Charles H. Suite 1, 46 Hereford St., Boston, Mass.	Instructor in Electrical Engineering, Massachusetts Institute of Technology	1907
Porter, Dwight Boston, Mass.	Professor of Hydraulic Engineering, Massachusetts Institute of Technology	1893
Porter, J. Madison Easton, Pa.	Professor of Civil Engineering, Lafayette College	1893
Porter, John B. Montreal, Quebec.	Professor of Mining Engineering, McGill University	1904
Porter, Royal A. 112 Livingston Ave., Syracuse, N. Y.	Associate Professor of Physics, Syracuse University	1908
Powell, Emery H. 1538 Madison Ave., Scranton, Pa.	Engineering Textbook Writer, International Correspondence Schools	1903
Pratt, Charles M. Brooklyn, N. Y.	President, Pratt Institute	1907
Pratt, Frederic B. Brooklyn, N. Y.	Secretary, Pratt Institute	1907
Price, Melvin Lafayette, Ind.		1900
Pryor, Frederick L. 421 4th Ave., Newark, N. J.	Professor of Experimental Engineering, Stevens Institute of Technology.	1908
Pupin, Michael I. New York, N. Y.	Professor of Electromechanics, Columbia University	1895
Puryear, Charles College Station, Tex.	Dean and Professor of Mathematics, Agricultural and Mechanical College of Texas	1901
Radtke, Albert A. 244 47th St., Chicago, Ill.	Professor of Electrical Engineering, Armour Institute of Technology	1907
Randall, Otis E. Providence, R. I.	Professor of Mechanics and Mechanical Drawing, Brown University	1903
Randolph, Lingan S. Blacksburg, Va.	Professor of Mechanical Engineering, Virginia Polytechnic Institute	1894
Ransom, James H. 323 University St., West Lafayette, Ind.	Professor of General Chemistry, Purdue University	1904
Rautenstrauch, Walter New York, N. Y.	Professor of Mechanical Engineering, Columbia University	1907

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
RAY, FRANKLIN A......... 137 King Ave., Columbus, Ohio.	Professor of Mine Engineering, Ohio State University.............	1906
RAYMOND, HOWARD M...... Chicago, Ill.	Dean of Engineering Studies and Professor of Experimental Physics, Armour Institute of Technology....	1904
RAYMOND, WILLIAM G..... Iowa City, Iowa.	Dean of College of Applied Science and Professor of Civil Engineering, State University of Iowa...........	1893
REBER, LOUIS E........... Madison, Wis.	Director, University Extension, University of Wisconsin...........	1893
REID, CLARENCE E......... 1848 101st St., N. E., Cleveland, Ohio.	Assistant Professor of Electrical Engineering, Case School of Applied Science	1907
REYNOLDS, HERMAN W..... Berkeley, Cal.	Assistant Professor of Mechanical Engineering, University of California..	1903
RICE, HERBERT A.......... 800 Indiana St., Lawrence, Kan.	Associate Professor of Civil Engineering, University of Kansas..........	1907
RICHARDS, CHARLES RUSS.. Lincoln, Neb.	Dean of Engineering and Professor of Mechanical Engineering, The University of Nebraska...............	1895
RICHARDS, CHAS. RUSSELL. New York, N. Y.	Director, Cooper Union for the Advancement of Science..............	1904
RICHARDS, ROBERT H....... Boston, Mass.	Professor of Mining Engineering and Metallurgy, Massachusetts Institute of Technology	1895
RICHEY, ALBERT S......... 12 Schussler Road, Worcester, Mass.	Professor of Electric Railway Engineering, Western Polytechnic Institute	1907
RICHTER, ARTHUR W....... Madison, Wis.	Professor of Experimental Engineering, University of Wisconsin.......	1894
RICKER, N. CLIFFORD...... Urbana, Ill.	Professor of Architecture, University of Illinois..............	1894
RIESENBERGER, ADAM ...... 546 Union Place, Weehawken, N. J.	Registrar and Treasurer, Stevens Institute of Technology.....	1904
RIGGS, NORMAN C......... Pittsburg, Pa.	Assistant Professor of Mathematics, Carnegie Technical Schools.........	1907
RIGGS, WALTER M......... Clemson College, S. C.	Professor of Electrical Engineering, and Director of the Department of Mechanical and Electrical Engineering, Clemson (A. and M.) College of South Carolina.................	1897

Name and Address.	Title.	Date of Membership.
Rittenhouse, Leon H..... Haverford, Pa.	Instructor in Engineering, Haverford College	1906
Robbins, Arthur G....... Boston, Mass.	Associate Professor of Topographical Engineering, Massachusetts Institute of Technology	1894
Roberts, W. J............ Medford, Oregon.	Consulting Engineer	1903
Robinson, Edward .... Burlington, Vt.	Professor of Mechanical Engineering, University of Vermont.............	1899
Robinson, Frederic H..... Newark, Del.	Professor of Civil Engineering, Delaware College	1894
Robinson, Stillman W.... 1353 Highland St., Columbus, Ohio.	Mechanical Engineer and Expert, Emeritus Professor of Mechanical Engineering, Ohio State University.	1893
Rockwell, Edward H..... 133 Powder House Blvd., Somerville, Mass.	Professor of Structural Engineering, Tufts College	1907
Rodhouse, Thomas J...... Columbia, Mo.	Assistant Professor of Hydraulic Engineering, University of Missouri...	1904
Roe, Joseph W............ 79 Trumbull St., New Haven, Conn.	Instructor in Mechanical Engineering, Sheffield Scientific School, Yale University	1908
Rogers, Allen .... Brooklyn, N. Y.	Instructor in Industrial Chemistry, Pratt Institute	1908
Rogers, Ralph .... 10 West Woodruff Ave., Columbus, Ohio.	Assistant Professor of Engineering Drawing, Ohio State University....	1908
Rondinella, Lino F....... 728 Stephen Girard Bldg., Philadelphia, Pa.	Head of Drawing Department, Central Manual Training High School of Philadelphia	1903
Rosebrugh, Thomas R..... Toronto, Ontario.	Associate Professor of Electrical Engineering, School of Practical Science.	1896
Rouillion, Louis .... 20 West 44th St., New York, N. Y.	Director, Mechanics' Institute.......	1906
Rowe, George H.......... 1211 Fisher Building, Chicago, Ill.	Consulting Engineer	1906
Rowland, Arthur J....... 4510 Osage Ave., Philadelphia, Pa.	Professor of Electrical Engineering, Drexel Institute	1903

Name and Address.	Title.	Date of Membership.
Rugan, Henry F. 4909 Carondelet St., New Orleans, La.	Associate Professor of Mechanic Arts and Erecting Engineering, Tulane University of Louisiana	1907
Russell, Walter B. Berkeley & Appleton Sts., Boston, Mass.	Director, Franklin Union	1903
Ryan, Harris J. Stanford University, Cal.	Professor of Electrical Engineering, Leland Stanford Junior University	1901
Sadler, Herbert C. 705 South State St., Ann Arbor, Mich.	Professor of Naval Architecture and Marine Engineering, University of Michigan	1907
Sanborn, Frank E. Columbus, Ohio.	Director, Industrial Arts Department, Ohio State University	1899
Sawyer, Arthur R. East Lansing, Mich.	Professor of Physics and Electrical Engineering, Michigan Agricultural College	1907
Schaphorst, William F. Agricultural College, New Mexico.	Assistant Professor Mechanical Engineering, New Mexico College of Agriculture and Mechanic Arts	1908
Schmidt, Edward C. 903 W. California Ave., Urbana, Ill.	Associate Professor of Railway Engineering, University of Illinois	1907
Schneider, Herman Cincinnati, Ohio.	Professor of Civil Engineering and Dean of the College of Engineering, University of Cincinnati	1903
Schuerman, William H. Nashville, Tenn.	Dean of the Engineering Department, Professor of Civil Engineering, Vanderbilt University	1895
Scott, Arthur C. Austin, Tex.	Professor of Electrical Engineering, University of Texas	1903
Scott, Charles F. Pittsburg, Pa.	Consulting Engineer, Westinghouse Electric and Manufacturing Company	1904
Scrugham, James G. Reno, Nev.	Professor of Mechanical Engineering, Nevada State University	1906
Sears, Thomas B. Station A, Lincoln, Neb.	Instructor in Civil Engineering, University of Nebraska	1908
Seaver, Henry L. 491 Boylston St., Boston, Mass.	Assistant Professor of English, Massachusetts Institute of Technology	1896

Name and Address.	Title.	Date of Membership.
Sedgwick, William T..... Boston, Mass.	Professor of Biology, Massachusetts Institute of Technology............	1896
Seery, Francis J.......... 113 Dryden Road, Ithaca, N. Y.	Assistant Professor of Civil Engineering, College of Engineering, Cornell University	1908
Sever, George F.......... New York, N. Y.	Professor of Electrical Engineering, Columbia University	1903
Sexton, Frederic H....... 197 Hollis St., Halifax, Nova Scotia.	President, Nova Scotia Technical College, and Director of Technical Education	1908
Shaad, George C.......... 2 Newbury Terrace, Newton Center, Mass.	Associate Professor of Electrical Engineering, Massachusetts Institute of Technology	1907
Shane, Adolph .... Ames, Iowa.	Associate Professor of Electrical Engineering, Iowa State College.......	1907
Shattuck, Harold Bemis. State College, Pa.	Associate Professor of Civil Engineering, The Pennsylvania State College.	1906
Shaw, Howard B.......... 511 Rollins Road, Columbia, Mo.	Professor of Electrical Engineering, University of Missouri.............	1907
Sheldon, Samuel .... Brooklyn, N. Y.	Professor of Physics and Electrical Engineering, Polytechnic Institute of Brooklyn	1903
Shepardson, George D.... Minneapolis, Minn.	Professor of Electrical Engineering, University of Minnesota...........	1895
Sherman, Christopher E.. 230 West 10th Ave., Columbus, Ohio.	Professor of Civil Engineering, Ohio State University.............	1907
Shipley, Sylvanus Carl.. 209 State St., S. E., Minneapolis, Minn.	Instructor in Shop Work, University of Minnesota...........	1908
Shoop, Charles Franklin Minneapolis, Minn.	Instructor in Experimental Engineering, University of Minnesota.......	1906
Short, Robert L.......... Cleveland, Ohio.	Mathematics Department, Technical High School	1902
Shoudy, William A....... 520 Hudson St., Hoboken, N. J.	Instructor in Experimental Engineering, Stevens Institute of Technology.	1907
Shuster, John W......... 235 West Gilman St., Madison, Wis.	Assistant Professor of Electrical Engineering, University of Wisconsin..	1907
Slichter, Charles S...... Madison, Wis.	Professor of Applied Mathematics, University of Wisconsin...........	1906

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
SLIPPY, RALPH B. 102 South Romine St., Urbana, Ill.	Instructor in Civil Engineering, University of Illinois	1907
SLOCUM, ROY H. Agricultural College, N. D.	Professor of Civil Engineering, North Dakota Agricultural College	1903
SLOCUM, STEPHEN E. Cincinnati, Ohio.	Professor of Applied Mathematics, University of Cincinnati	1906
SMART, GEORGE Browning Building, Cleveland, Ohio.	Editor, *Iron Trade Review*	1907
SMITH, ALBERT W. 1101 E. Madison Ave., Cleveland, Ohio.	Professor of Metallurgy, Case School of Applied Science	1904
SMITH, ALTON L. Worcester, Mass.	Professor of Drawing and Machine Design, Worcester Polytechnic Institute	1902
SMITH, ANSON W. Brooklyn, N. Y.	Instructor in Mechanical Drawing, Pratt Institute	1907
SMITH, EARL B. Philadelphia, Pa.	Instructor in Charge of Mechanical Engineering Laboratories, Drexel Institute	1906
SMITH, HAROLD B. Worcester, Mass.	Professor of Electrical Engineering, Worcester Polytechnic Institute	1898
SMITH, HARRY E. 1346 West Wood St., Decatur, Ill.	Professor of Mechanical Engineering, James Millikin University	1895
SMITH, HERBERT S. S. Princeton, N. J.	Professor of Civil Engineering, Princeton University	1894
SMITH, LEONARD S. 938 University Ave., Madison, Wis.	Associate Professor of Topographic and Geodetic Engineering, University of Wisconsin	1903
SMITH, PERCY F. 330 Willow St., New Haven, Conn.	Professor of Mathematics, Sheffield Scientific School, Yale University	1908
SMITH, RALPH O. New Brunswick, N. J.	Rutgers College	1907
SMULL, THOMAS J., JR. Ada, Ohio.	Dean of College of Engineering, Ohio Northern University	1907
SMYTH, HENRY L. 9 Buckingham St., Cambridge, Mass.	Professor of Mining, Harvard University	1907

Name and Address.	Title.	Date of Membership.
Snow, Charles H......... New York, N. Y.	Dean of School of Applied Science, and Professor of Civil Engineering, New York University..............	1895
Snow, Walter B......... 29 Russell Ave., Watertown, Mass.	Publicity Engineer, 170 Summer St., Boston, Mass.	1899
Solberg, Halvor C........ Brookings, S. D.	Professor of Mechanical Engineering, South Dakota Agricultural College..	1894
Songe, Adolph .... Langley Ave., St. Joseph, Mich.	Mechanical Engineer, Chicago, Ill.....	1907
Spalding, Frederick P.... Columbia, Mo.	Professor of Civil Engineering, University of Missouri................	1893
Spangler, Henry W....... Philadelphia, Pa.	Professor of Mechanical Engineering, University of Pennsylvania........	1895
Sparks, Edwin Erle...... State College, Pa.	President, The Pennsylvania State College	1908
Sperr, Frederick W....... Houghton, Mich.	Professor of Civil and Mining Engineering, Michigan College of Mines..	1896
Spinney, Louis B......... Ames, Iowa.	Professor of Physics and Electrical Engineering, Iowa State College....	1899
Spofford, Charles M...... Brooklyn, N. Y.	Professor of Civil Engineering, Polytechnic Institute of Brooklyn..	1904
Springer, Frank W....... Minneapolis, Minn.	Professor of Electrical Engineering, University of Minnesota...........	1896
Stanford, J. Verne....... Engineering Building, Philadelphia, Pa.	Assistant Professor of Mechanical Engineering, University of Pennsylvania	1907
Stanwood, James B....... Cincinnati, Ohio.	Vice-President and Engineer, Houston, Stanwood & Gamble Company..	1894
Steel, Alvin A........... Fayetteville, Ark.	Associate Professor of Geology and Mining, University of Arkansas.....	1905
Stevens, Edward F........ Brooklyn, N. Y.	Head of Applied Science, Reference Department, Pratt Institute Free Library	1908
Stewart, Charles E...... 32 Dearborn Road, Tufts College, Mass.	Assistant Professor Mechanic Arts, Tufts College	1908
Stewart, Louis B......... Toronto, Ontario.	Lecturer in Surveying, School of Practical Science	1897

Name and Address.	Title.	Date of Membership.
Stoek, Harry H. 809 Quincy Ave., Scranton, Pa.	Editor, *Mines and Minerals,* International Textbook Co.	1907
Stone, Charles A. 147 Milk St., Boston, Mass.	Member of the Firm of Stone and Webster, Consulting Engineers	1907
Stone, E. Albert Fredericton, N. B.	Dean of Engineering School and Professor of Civil Engineering, University of New Brunswick	1907
Storm, Edwin R. 160 Fifth Ave., New York, N. Y.	Instructor of Descriptive Geometry, Cooper Union for the Advancement of Science	1908
Stout, Oscar V. P. Lincoln, Neb.	Head Professor of Civil Engineering, University of Nebraska	1894
Strong, Frank Lawrence, Kan.	Chancellor, University of Kansas	1907
Stubbs, Joseph E. Reno, Nev.	President, Nevada State University	1897
Swain, George F. Boston, Mass.	Professor of Civil Engineering, Massachusetts Institute of Technology	1893
Swett, George W. 17 Gray St., Cambridge, Mass.	Instructor in Mechanical Engineering, Massachusetts Institute of Technology	1907
Swift, Walter Sheffield, England.	Secretary of Technical Department, University College	1902
Talbot, Arthur N. Urbana, Ill.	Professor of Municipal and Sanitary Engineering, and in Charge of Theoretical and Applied Mechanics, University of Illinois	1893
Talbot, Henry P. Boston, Mass.	Professor of Analytical Chemistry, Massachusetts Institute of Technology	1903
Tannatt, Eben Tappan 715 S. Grand Ave., Bozeman, Mont.	Professor of Civil Engineering, Montana State College of Agriculture and Mechanic Arts	1907
Taylor, Thomas U. Austin, Tex.	Professor of Civil Engineering, University of Texas	1902
Taylor, William D. Chicago, Ill.	Chief Engineer, Chicago and Alton Railway Co.	1894
Telleen, J. Martin 1482 East 116th St., Cleveland, Ohio.	Assistant Professor of English, Case School of Applied Science	1908

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
THACH, CHARLES C. Auburn, Ala.	President, Alabama Polytechnic Institute	1905
THALER, JOSEPH A. Bozeman, Mont.	Professor of Electrical Engineering, Montana College of Agriculture and Mechanic Arts	1901
THOMAS, ALBERT L. Auburn, Ala.	Instructor in Machine Work and Mechanical Drawing, Alabama Polytechnic Institute	1907
THOMAS, CARL C. 1804 Madison St., Madison, Wis.	Professor of Steam and Gas Engineering, University of Wisconsin	1908
THOMAS, CHARLES W. New York, N. Y.	Mechanical Department, Columbia University	1904
THOMAS, EVAN 23 Hickok Place, Burlington, Vt.	Assistant Professor of Mathematics, Engineering Department, University of Vermont	1908
THOMAS, ROBERT G. Charleston, S. C.	Professor of Mathematics and Engineering, South Carolina Military Academy	1894
THOMPSON, G. SAX 689 Second Ave., Troy, N. Y.	Assistant in Department of Mechanics, Rensselaer Polytechnic Institute	1907
THOMPSON, WILLIAM O. Columbus, Ohio.	President, Ohio State University	1907
THORNBURG, CHARLES L. South Bethlehem, Pa.	Professor of Mathematics and Astronomy, Lehigh University	1894
THORPE, JOHN C. 203 West Green St., Urbana, Ill.	Assistant Professor of Steam Engineering, University of Illinois	1907
TIMBIE, WILLIAM H. Brooklyn, N. Y.	Instructor in Physics, Pratt Institute	1908
TISDEL, FREDERICK MONROE. Germany.	Address mail c/o E. E. Munroe, 125 Washington Street, Brighton, Mass.	1907
TITSWORTH, ALFRED A. 590 George St., New Brunswick, N. J.	Professor of Civil Engineering and Graphics, Rutgers College	1896
TOMPKINS, STONEWALL Miller School, Va.	Director, Engineering Department, Miller M. L. School	1907

Name and Address.	Title.	Date of Membership.
Touceda, Enrique A. B'way cor. Thatcher St., Albany, N. Y.	Professor of Metallurgy, Rensselaer Polytechnic Institute, Troy, N. Y.	1907
Towle, William Mason 27 Main St., Potsdam, N. Y.	Superintendent of Shops, Clarkson School of Technology	1895
Townsend, Edgar J. 510 John St., Champaign, Ill.	Professor of Mathematics, Dean of the College of Science, University of Illinois	1906
Tracy, John C. 345 Winthrop Ave., New Haven, Conn.	Assistant Professor of Structural Engineering, Sheffield Scientific School, Yale University	1907
Trask, Bibney E. Burgh Street, Granville, Ohio.	Professor of Civil Engineering, Denison University	1907
Turneaure, Frederick E. Madison, Wis.	Dean of the College of Engineering, University of Wisconsin	1894
Turner Daniel L. 220 West 107th St., New York, N. Y.	General Inspector of Stations, Public Service Commission for the First District, New York City	1898
Turner, William P. Lafayette, Ind.	Professor of Practical Mechanics, Purdue University	1900
Turrill, Sherman M. Prospect Place, Potsdam, N. Y.	Professor of Civil Engineering, in charge of the Department, Clarkson School of Technology	1907
Tyler, Harry W. 491 Boylston St., Boston, Mass.	Professor of Mathematics, Massachusetts Institute of Technology	1894
Van Hise, Charles R. Madison, Wis.	President, University of Wisconsin	1904
Van Ness, L. G. 22 North Second St., Memphis, Tenn.	Secretary, Merchants' Power Co.	1907
Van Ornum, John L. St. Louis, Mo.	Professor of Civil Engineering, Washington University	1895
Vedder, Herman K. East Lansing, Mich.	Professor of Mathematics and Civil Engineering, Michigan Agricultural College	1894
von Voigtlander, Oscar F. 317½ Seward Place, Schenectady, N. Y.	Instructor in Civil Engineering, Union College	1908

Name and Address.	Title.	Date of Membership.
Vose, Fred Hale 1382A Clara Ave., St. Louis, Mo.	Assistant Professor of Mechanical Engineering, Washington University	1907
Vosskuehler, Joseph H. Madison, Wis.	Assistant Professor of Machine Design, University of Wisconsin	1902
Votey, J. William Burlington, Vt.	Professor of Civil Engineering and Dean of Engineering Department, University of Vermont	1902
Waddell, J. A. L. 608 New Nelson Bldg., Kansas City, Mo.	Consulting Bridge Engineer, Waddell and Harrington	1893
Wadsworth, Joel E. 22 Morsemere Place, Yonkers, N. Y.	Resident Engineer, American Bridge Co.	1895
Wadsworth, M. Edward Pittsburg, Pa.	Dean, School of Mines, University of Pittsburg	1895
Wait, John Cassan 3607 Broadway, New York, N. Y.	Attorney-at-Law, Wait & Foster, 38 Park Row	1907
Waldo, Clarence A. St. Louis, Mo.	Professor of Mathematics, Washington University	1897
Walker, Elton D. State College, Pa.	Professor of Hydraulic and Sanitary Engineering, The Pennsylvania State College	1895
Walker, P. F. 1301 Ohio St., Lawrence, Kans.	Professor of Mechanical Engineering and Director of Fowler Shops, University of Kansas	1907
Wallace, Jacob H. Boulder, Colo.	Assistant Professor, in charge of General Engineering Drawing, University of Colorado	1905
Wallace, John F. 165 Broadway, New York, N. Y.	Consulting Engineer	1903
Ward, Kenneth B. Columbus, Ohio.	Assistant in Civil Engineering, Ohio State University	1907
Waterbury, Leslie A. Tucson, Ariz.	Professor of Civil Engineering, University of Arizona	1906
Waterman, Earle L. P. O. Box 502, State College, Pa.	Assistant in Civil Engineering, The Pennsylvania State College	1907

Name and Address.	Title.	Date of Membership.
Webb, J. Burkitt......... Hoboken, N. J.	Consulting Engineer in Mathematics, Mechanics and Physics.............	1906
Webber, Roy I............ State College, Pa.	Assistant Professor of Structural Engineering, The Pennsylvania State College	1907
Webster, Edwin S........ 147 Milk St., Boston, Mass.	Member of the Firm of Stone and Webster, Consulting Engineers......	1907
Wendt, Wylie B.......... East Lansing, Mich.	Instructor in Civil Engineering, Michigan Agricultural College......	1908
Wendell, George V....... 400 West 118th St., New York, N. Y.	Professor of Physics, Stevens Institute of Technology....	1900
Wessling, Albert G....... 549 Milton St., Cincinnati, Ohio.	Assistant Engineer, Bullock Electric Mfg. Co., Electrical Department, Allis-Chalmers Co.	1907
Westcott, Arthur L...... 906 Lowry St., Columbia, Mo.	Assistant Professor of Experimental Engineering, University of Missouri.	1908
Wheeler, Earl .... Washington Barracks, Washington, D. C.	Head of Department of Electrical and Mechanical Engineering, United States Engineering School..........	1907
Wheeler, Lynde P........ 124 Linden St., New Haven, Conn.	Assistant Professor of Physics, Sheffield Scientific School, Yale University	1908
Whipple, George C........ 103 Park Ave., New York, N. Y.	Consulting Engineer, Firm of Hazen and Whipple	1896
White, James M.......... Champaign, Ill.	Professor of Architectural Engineering and Supervising Architect, University of Illinois.................	1900
Wiley, William O........ 43 and 45 E. 19th St., New York, N. Y.	Publisher of Scientific Books, Secretary, John Wiley and Sons.........	1904
Willard, Arthur Cutts.. 2204 Decatur Place, N.W., Washington, D. C.	Assistant Professor of Mechanical Engineering, George Washington University	1907
Williams, Frank B....... Worcester, Mass.	Professor of Mathematics, Clark College	1901
Williams, Gardner S..... 1503 Washtenaw Ave., Ann Arbor, Mich.	Professor of Civil, Hydraulic and Sanitary Engineering, University of Michigan	1907

Name and Address.	Title.	Date of Membership.
Williams, Joseph D. Box 66, Fort Plain, N. Y.	Leveler, Department of State Engineer and Surveyor, Section No. 3, Erie Canal	1907
Williams, Sylvester N. Mt. Vernon, Iowa.	Professor of Civil Engineering, Cornell College	1893
Williston, Arthur L. Brooklyn, N. Y.	Director, Department of Science and Technology, Pratt Institute	1897
Wilmore, John J. Auburn, Ala.	Dean, School of Engineering, and Professor of Mechanical Engineering, Alabama Polytechnic Institute	1894
Wilson, Alexander M. 326 Harrison Ave., Lexington, Ky.	Professor of Electrical Engineering, State University of Kentucky	1907
Wilson, Birton N. 241 College Ave., Fayetteville, Ark.	Professor of Mechanical Engineering, and Superintendent of Mechanic Arts, University of Arkansas	1907
Wilson, Delonza Tate Cleveland, Ohio.	Assistant Professor of Mathematics and Astronomy, Case School of Applied Science	1907
Wilson, Victor T. East Lansing, Mich.	Professor of Drawing and Design, Michigan Agricultural College	1906
Withrow, James R. Columbus, Ohio.	Assistant Professor of Chemistry, Ohio State University	1907
Wood, Arthur J. State College, Pa.	Associate Professor of Experimental Engineering, The Pennsylvania State College	1898
Woodbridge, S. Homer Boston, Mass.	Associate Professor of Heating and Ventilation, Massachusetts Institute of Technology	1904
Woodward, Calvin M. St. Louis, Mo.	Professor of Mathematics and Applied Mechanics and Dean of the School of Engineering and Architecture, Washington University	1894
Woodward, Robert S. 1513 Sixteenth St., Washington, D. C.	President, Carnegie Institution of Washington, Washington, D. C.	1894
Wrentmore, Clarence G. 933 Forest Ave., Ann Arbor, Mich.	Assistant Professor of Civil Engineering, University of Michigan	1904
Wright, Arthur S. 2072 Cornell Road, Cleveland, Ohio.	Professor of Modern Languages, Case School of Applied Science	1907

Name and Address.	Title.	Date of Membership.
Yerzley, William Alfred. 14 Garden St., Potsdam, N. Y.	Professor of Mechanical Engineering, Thomas Clarkson School of Technology	1907
Young, Clinton M. 407 W. Hancock St., Lawrence, Kan.	Associate Professor of Mining Engineering, University of Kansas	1907
Young, Daniel A. 320 Lenox Road, Schenectady, N. Y.	Instructor in Civil Engineering, Union College	1908
Young, Gilbert A. 409 University Ave., West Lafayette, Ind.	Assistant Professor of Mechanical Engineering, Purdue University	1907
Young, Lewis E. Golden, Colo.	Professor of Mining, Colorado School of Mines	1903
Zeleny, Anthony 321 Church St., S. E., Minneapolis, Minn.	Assistant Professor of Physics, University of Minnesota	1907
Zimmerman, Oliver B. Charles City, Iowa.	Mechanical Engineer and Chief Draftsman, Hart-Parr Co.	1902
Ziwet, Alexander Ann Arbor, Mich.	Professor of Mathematics, University of Michigan	1897

GEOGRAPHICAL DISTRIBUTION OF MEMBERS.

Names in italics are those of persons not engaged in teaching.

Alabama.—Auburn: R. L. Brown; B. H. Crenshaw; G. N. Mitcham; C. C. Thach; A. L. Thomas; J. J. Wilmore; (6). **Montevallo:** T. W. Palmer. **Talladega:** *H. H. Kyser.* **University:** E. B. Kay.

Arizona.—Tucson: W. W. Henley; L. A. Waterbury; (2).

Arkansas.—Fayetteville: W. N. Gladson; J. J. Knoch; A. A. Steel; B. N. Wilson; (4).

California.—Berkeley: S. B. Christy; C. Derleth, Jr.; H. W. Reynolds; (3). **Pasadena:** H. T. Clifton. **Stanford University:** W. F. Durand; L. M. Hoskins; C. D. Marx; H. J. Ryan; (4).

Colorado.—Boulder: H. S. Evans; J. A. Hunter; D. R. Jenkins; M. S. Ketchum; A. P. Poorman; J. H. Wallace; (6). **Colorado Springs:** F. Cajori. **Fort Collins:** L. G. Carpenter; R. W. Gay; J. W. Lawrence; C. A. Lory; (4). **Golden:** V. C. Anderson; C. R. Burger; L. E. Young; (3).

Connecticut.—New Haven: S. E. Barney; R. H. Chittenden; A. J. Du Bois; C. S. Farnham; L. D. Huntoon; E. H. Lockwood; H. B. North; J. W. Roe; P. F. Smith; J. C. Tracy; L. P. Wheeler; (11).

Delaware.—Newark: G. A. Harter; F. H. Robinson; (2).

District of Columbia.—Washington: (Carnegie Institution) R. S. Woodward. (George Washington University) P. Betts; H. L. Hodgkins; A. C. Willard; (3). (U. S. Army Engineering School) E. Wheeler. (City) *B. R. Green; J. F. Hayford; J. A. Holmes;* (3).

Florida.—Gainesville: J. R. Benton; N. H. Cox; (2).

Georgia.—Dahlonega: J. F. O'Byrne.

Idaho.—Alberta: J. A. Green. **Moscow:** S. E. Hutton; C. N. Little; (2).

Illinois.—Champaign: I. O. Baker; A. R. Bench; H. B. Dirks; H. F. Moore; L. G. Parker; E. J. Townsend; J. M. White; (7). **Chicago:** (Armour Inst.) W. E. Barrows, Jr.; R. Burnham; C. E. Freeman; L. C. Monin; D. P. Moreton; C. E. Paul; A. A. Radtke; H. M. Raymond; (8). (Lewis Inst.) H. E. Cobb; C. E. DePuy; A. W. Moseley; (3). (University of Chicago) C. Kinsley. (City) *B. J. Arnold; O. Bates; A. Bement; G. M. Brill; W. M. Camp; O. Chanute; A. S. Hibbard; G. T. Horton; R. Modjeski; G. H. Rowe; W. D. Taylor;* (11). **Decatur:** H. E. Smith. **Evanston:** O. H. Basquin; A. W. Harris; (2). **Peoria:** F. Bishop; F. H. Evans; (2). **Urbana:** L. P. Breckenridge; J. P. Brooks; M. Brooks; F. O. Dufour; W. V. Dunkin; M. L. Enger; J. H. Gill; G. A. Goodenough; W. F. M. Goss; C. T. Knipp; O. A. Leutwiler; C. W. Malcolm; N. C. Ricker; E. C. Schmidt; R. B.

Slippy; A. N. Talbot; J. C. Thorpe; (17 + 7 = 24 in University of Ill.).

Indiana.—Lafayette: C. H. Benjamin; A. W. Cole; S. Coulter; L. E. Endsley; J. W. Esterline; H. O. Garman; E. L. Hancock; C. F. Harding; W. K. Hatt; J. D. Hoffman; A. M. Kenyon; C. H. Lawrance; L. V. Ludy; H. T. Plumb; J. H. Ransom; W. P. Turner; G. A. Young; (17). (City) *M. Price.* **Richmond:** W. C. McNown. **Terre Haute:** M. A. Howe; C. L. Mees; (2).

Iowa.—Ames: S. W. Beyer; F. A. Fish; H. C. Ford; A. H. Hoffman; A. Marston; W. H. Meeker; A. Shane; L. B. Spinney; (8). **Charles City:** *O. B. Zimmerman.* **Iowa City:** P. S. Biegler; A. H. Ford; F. G. Higbee; B. J. Lambert; W. G. Raymond; (5). **Mt. Vernon:** S. N. Williams.

Kansas.—Lawrence: B. J. Dalton; W. C. Hoad; A. K. Hubbard; F. O. Marvin; J. D. Newton; H. A. Rice; F. Strong; P. F. Walker; C. M. Young; (9). **Manhattan:** E. B. McCormick.

Kentucky.—Lexington: F. P. Anderson; C. J. Norwood; A. M. Wilson; (3).

Louisiana.—Baton Rouge: T. W. Atkinson; A. M. Herget; (2). **New Orleans:** D. S. Anderson; W. H. Creighton; W. B. Gregory; H. F. Rugan; (4).

Maine.—Brunswick: H. B. Hastings. **Orono:** H. S. Boardman; A. C. Jewett; (2).

Massachusetts.—Amherst: J. E. Ostrander. **Boston:** (Franklin Union) W. B. Russell. (Mass. Inst. Tech.) C. L. Adams; C. F. Allen; R. D. Bradbury; C. B. Breed; A. E. Burton; H. E. Clifford; H. G. Crane; C. E. Fuller; N. R. George, Jr.; H. W. Hayward; H. O. Hofman; J. W. Howard; D. C. Jackson; W. H. James; W. A. Johnston; G. Lanza; R. R. Lawrence; W. H. Lawrence; G. F. Loughlin; A. L. Merrill; L. E. Moore; W. E. Mott; *J. P. Munroe;* C. L. Norton; A. A. Noyes; C. F. Park; C. H. Porter; D. Porter; R. H. Richards; A. G. Robbins; H. L. Seaver; W. T. Sedgwick; G. C. Shaad; G. F. Swain; G. W. Swett; H. P. Talbot; H. W. Tyler; S. H. Woodbridge; (38). (City) *H. K. Barrows; C. A. Chandler; W. B. Snow; C. A. Stone; E. S. Webster;* (5). **Cambridge:** C. A. Adams; I. N. Hollis; H. J. Hughes; E. V. Huntington; L. J. Johnson; F. L. Kennedy; H. L. Smyth; (7). **Dorchester Center:** J. H. Hawes. **Tufts College:** G. C. Anthony; C. D. Bray; C. H. Chase; W. L. Hooper; E. H. Rockwell; C. E. Stewart; (6). **Worcester:** (Clark College) F. B. Williams. (W. P. I.) C. M. Allen; A. D. Butterfield; E. A. Engler; H. P. Fairfield; A. W. French; H. C. Ives; C. D. Knight; J. O. Phelon; A. S. Richey; A. L. Smith; H. B. Smith; (11).

Michigan.—Ann Arbor: J. R. Allen; M. E. Cooley; C. S. Denison; W. S. Hazelton; W. L. Miggett; J. A. Moyer; H. P. Noble; H. C.

Sadler; G. S. Williams; C. G. Wrentmore; A. Ziwet; (11). **Calumet:** *J. MacNaughton.* **East Lansing:** L. L. Appleyard; W. Babcock; E. N. Bates; G. W. Bissell; W. L. Lodge; J. A. Polson; A. R. Sawyer; H. K. Vedder; W. B. Wendt; V. T. Wilson; (10). **Houghton:** L. S. Austin; G. L. Christensen; D. Copeland; J. Fisher, Jr.; E. D. Grant; O. P. Hood; F. W. McNair; F. W. Sperr; (8). **Ishpeming:** *M. M. Duncan.* **Marquette:** *J. M. Longyear.* **Painesdale:** *F. W. Denton.* **Vulcan:** *W. Kelly.* **St. Joseph:** *A. Songe.* **Lapeer:** *F. Morley.*

Minnesota.—Minneapolis: F. H. Bass; W. E. Brooke; E. H. Comstock; F. H. Constant; H. T. Eddy; J. J. Flather; G. B. Frankforter; H. D. Frary; B. F. Groat; A. E. Haynes; O. Hovda; F. S. Jones; W. H. Kavanaugh; J. V. Martenis; B. L. Newkirk; G. D. Shepardson; S. C. Shipley; C. F. Shoop; F. W. Springer; A. Zeleny; (20).

Mississippi.—University: W. H. Drane; A. Hume; J. W. Johnson; (3).

Missouri.—Columbia: L. M. Defoe; H. W. Hibbard; A. L. Hyde; W. A. Miller; T. J. Rodhouse; H. B. Shaw; F. P. Spalding; A. L. Westcott; (8). **Kansas City:** (M. T. H. S.) J. M. Kent. (City) *J. L. Harrington; I. G. Hedrick; A. Maitland, Jr.; W. K. Palmer; J. A. L. Waddell;* (5). **Rolla:** E. G. Harris; G. E. Ladd; A. L. McRae; (3). **St. Louis:** (High School) S. H. Moore. (Washington Univ.) A. S. Langsdorf; E. L. Ohle; J. L. Van Ornum; F. H. Vose; C. A. Waldo; C. M. Woodward; (6). (City) *W. H. Bixby; R. B. Brinsmade;* (2).

Montana.—Bozeman: E. T. Tannatt; J. A. Thaler; (2).

Nebraska.—Lincoln: G. R. Chatburn; E. W. Davis; G. H. Morse; C. R. Richards; T. B. Sears; O. V. P. Stout; (6). **Luning:** *A. N. Clark.* **Reno:** J. G. Scrugham; J. E. Stubbs; (2).

New Hampshire.—Durham: A. F. Nesbit; C. H. Pettee; (2). **Hanover:** R. Fletcher; J. V. Hazen; C. A. Holden; (3).

New Jersey.—East Orange: *N. C. Grover.* **Hoboken:** (Stevens) J. E. Denton; F. D. Furman; A. F. Ganz; C. O. Gunther; A. C. Humphreys; C. B. LePage; L. A. Martin, Jr.; J. C. Ostrup; F. L. Pryor; A. Riesenberger; W. A. Shoudy; G. V. Wendell; (12). (City) *J. B. Webb.* **Princeton:** H. S. S. Smith. **New Brunswick:** R. C. H. Heck; R. O. Smith; A. A. Titsworth; (3). **Short Hills:** *J. J. Carty.* **South Orange:** *C. P. Poole.*

New Mexico.—Albuquerque: C. B. Gibbons. **Agricultural College:** W. F. Schaphorst.

New York.—Albany: *A. D. Dean; H. A. Gehring;* (2). **Brooklyn:** (Polytechnic Inst.) F. W. Atkinson; W. D. Ennis; S. Sheldon; C. M. Spofford; (4). (Pratt Inst.) W. A. Ballou; S. S. Edmands; J. M. Jameson; W. J. Kaup; E. H. Koch, Jr.; E. J. Kunze; M. C. Maxwell; J. H. Morecroft; *C. M. Pratt; F. B. Pratt;* A.

Rogers; A. W. Smith; *E. F. Stevens;* W. H. Timbie; A. L. Williston; (15). **Fort Plain:** *J. D. Williams;* **Ithaca:** F. A. Barnes; S. L. Boothroyd; R. C. Carpenter; C. L. Crandall; E. E. Haskell; H. S. Jacoby; G. S. Macomber; D. A. Molitor; H. H. Norris; F. J. Seery; (10). **New York:** (Columbia Univ.) F. B. Abbott; A. Black; W. H. Burr; F. A. Goetze; C. E. Lucke; C. E. Morrison; H. S. Monroe; M. I. Pupin; W. Rautenstrauch; G. F. Sever; C. W. Thomas; (11). (Cooper Union) A. Ball; H. C. Enders; F. M. Hartmann; C. R. Richards; E. R. Storm; (5). (Mechanics Inst.) L. Rouillion. (N. Y. Univ.) A. Haring; C. E. Houghton; C. H. Snow; (3). (City) *M. R. Bump; E. Caldwell; E. L. Corthell; H. L. Doherty; L. Duncan; E. S. Farwell; G. H. Frost; H. P. Gillette; F. A. Halsey; D. S. Jacobus; B. Jones, Jr.; C. Kirchhoff; M. Merriman; D. E. Moran; F. W. Parsons; D. L. Turner; J. C. Wait; J. F. Wallace; G. C. Whipple; W. O. Wiley;* (20). **Potsdam:** W. S. Aldrich; B. B. Brackett; W. M. Towle; S. M. Turrill; W. A. Yerzley; (5). **Schenectady:** O. J. Ferguson; W. A. Garrison; J. W. Hughes; O. H. Landreth; O. F. Von Voigtlander; D. A. Young; (6). **Syracuse:** R. A. Porter. (City) *J. H. Barr; W. Kent;* (2). **Troy:** A. M. Greene, Jr.; G. S. Thompson; E. A. Touceda; (3). **Wellsville:** *C. V. Kerr.* **Yonkers:** J. S. Brown; J. E. Wadsworth; (2).

North Carolina.—Chapel Hill: A. H. Patterson. **West Raleigh:** W. H. Browne, Jr.

North Dakota.—Agricultural College: R. H. Slocum. **Grand Forks:** E. J. Babcock; A. J. Becker; E. F. Chandler; C. H. Crouch; (4).

Ohio.—Ada: T. J. Smull, Jr. **Cincinnati:** F. E. Ayer; J. T. Faig; A. L. Jenkins; H. Schneider; S. E. Slocum; (5). (City) *H. T. Eddy; J. B. Stanwood; A. G. Wessling;* (3). **Cleveland:** (Case School) F. M. Comstock; H. B. Dates; R. G. Dukes; R. H. Fernald; T. M. Focke; C. S. Howe; C. F. Mabery; D. C. Miller; F. H. Neff; C. E. Reid; A. W. Smith; J. M. Telleen; D. T. Wilson; A. S. Wright; (14). (Tech. H. S.) R. L. Short. (City) *F. W. Ballard; H. M. Lane; G. Smart;* (3). **Columbus:** (O. S. U.) R. D. Bohannan; J. E. Boyd; J. N. Bradford; F. C. Caldwell; F. H. Eno; T. E. French; E. A. Hitchcock; J. H. Hunt; H. Judd; W. A. Knight; N. W. Lord; W. T. Magruder; C. T. Morris; E. Orton, Jr.; F. A. Ray; S. W. Robinson; R. Rogers; F. E. Sanborn; C. E. Sherman; W. O. Thompson; K. B. Ward; J. R. Withrow; (22). **Dayton:** *R. S. King.* **Delaware:** W. G. Hornell. **Granville:** B. E. Trask.

Oklahoma.—Wilburton: G. E. Ladd.

Oregon.—Corvallis: G. A. Covell. **Eugene:** F. G. Frink. **Medford:** *W. J. Roberts.*

Pennylvania.—**Altoona:** *C. B. Dudley.* **Easton:** J. M. Porter. **Haverford:** L. H. Rittenhouse. **Lewisburg:** C. A. Lindemann. **Media:** L. M. Arkley. **Philadelphia:** (Central M. T. H. S.) L. F. Rondinella. (Drexel Inst.) A. J. Rowland; E. B. Smith; (2). (Univ. of Pa.) H. B. Evans; E. L. Ingram; E. Marburg; H. W. Spangler; J. V. Stanford; (5). (City) *A. W. Ayer; A. T. Bruegel; L. M. Haupt; T. Olsen;* (4). **Pittsburg:** (Carnegie Tech. Sch.) C. B. Connelley; F. E. Foss; A. A. Hamerschlag; C. C. Leeds; J. H. Leete; N. C. Riggs; (6). (Univ. of Pittsburg) M. E. Wadsworth. (Western Univ. of Pa.) A. E. Frost. (City) *D. Carhart; A. Kingsbury; C. F. Scott;* (3). **Scranton:** J. J. Clark; E. H. Powell; (2). (City) *H. H. Stoek.* **South Bethlehem:** H. S. Drinker; W. Esty; W. S. Franklin; A. W. Klein; P. A. Lambert; F. P. McKibben; C. L. Thornburg; (7). **State College:** L. F. Adams; W. S. Ayars; H. Diemer; H. V. Egbert; B. G. Fogg; S. D. Fowler; J. P. Jackson; C. P. Linville; G. E. Munroe; R. E. Myers; H. B. Shattuck; E. E. Sparks; E. D. Walker; E. L. Waterman; R. I. Webber; A. J. Wood; (16). **Wilkinsburg:** *H. W. Brown; C. R. Dooley;* (2).

Rhode Island.—**Providence:** A. H. Blanchard; J. A. Brooks; H. B. Drowne; J. E. Hill; W. H. Kenerson; T. M. Phetteplace; O. E. Randall; (7).

South Carolina.—**Clemson College:** W. M. Riggs. **Charleston:** R. G. Thomas.

South Dakota.—**Brookings:** H. B. Mathews; H. C. Solberg; (2). **Vermillion:** A. B. McDaniel.

Tennessee.—**Knoxville:** B. Ayres; W. W. Carson; R. C. Matthews; (3). (City) *F. R. Jones.* **Memphis:** *L. G. Van Ness.* **Nashville:** W. H. Schuerman. **Sewanee:** S. M. Barton.

Texas.—**Austin:** H. Y. Benedict; A. C. Scott; T. U. Taylor; (3). **Beaumont:** *A. C. Love.* **College Station:** N. H. Brown; E. J. Fermier; F. E. Giesecke; J. C. Nagle; C. Puryear; (5).

Utah.—**Logan:** *J. Jenson.* **Provo:** *P. N. Nunn.* **Salt Lake City:** W. C. Ebaugh; R. R. Lyman; J. F. Merrill; (3). (City) *G. M. Bacon.*

Vermont.—**Burlington:** J. W. Elliott; W. H. Freedman; C. H. Pierce; E. Robinson; E. Thomas; J. W. Votey; (6).

Virginia.—**Blacksburg:** J. S. Johnson; L. S. Randolph; (2). **Lexington:** E. W. Nichols. **Miller School:** S. Tompkins.

Wahington.—**Seattle:** C. E. Fowler; A. H. Fuller; G. I. Gavett; E. Haviland, Jr.; C. E. Magnusson; E. J. McCaustland; C. C. More; F. A. Osborn; (8).

West Virginia.—**Morgantown:** W. H. Boughton; F. L. Emory; C. R. Jones; F. L. Kortright; (4).

Wisconsin.—**Madison:** M. C. Beebe; C. F. Burgess; J. G. D. Mack; E. R. Maurer; D. W. Mead; A. V. Millar; E. B. Norris; W. D.

Pence; J. D. Phillips; L. E. Reber; A. W. Richter; J. W. Shuster; C. S. Slichter; L. S. Smith; C. C. Thomas; F. E. Turneaure; C. R. Van Hise; J. H. Vosskuehler; (18). (City) *J. T. Atwood.* **Milwaukee:** *G. H. Benzenberg;* (Sch. of Trades) C. F. Perry. **Platteville:** R. B. Brinsmade.

Australia.—Melbourne: *E. Mead.* **Sydney, N. S. W.:** S. H. Barraclough.

Canada.—Montreal, Quebec: H. T. Bovey; R. B. Owens; J. B. Porter; (3). **Toronto, Ontario:** (Sch. of Practical Sci.) T. R. Rosebrugh; L. B. Stewart; (2). (Univ. of Toronto) J. Galbraith; P. Gillespie; (2). **Winnepeg, Manitoba:** E. E. Brydone-Jack.

England.—Sheffield: W. Swift.

Germany. *F. E. Tisdel.*

Italy.—Florence: T. C. Mendenhall.

Mexico.—Zamora: *W. D. Appleton.*

New Brunswick.—Fredericton: E. A. Stone.

Nova Scotia.—Halifax: F. H. Sexton.

Philippine Islands.—Manila: *F. A. Dalburg; E. L. Lundgren;* (2).

GEOGRAPHICAL SUMMARY OF MEMBERS.

Alabama	9
Arizona	2
Arkansas	4
California	8
Colorado	14
Connecticut	11
Delaware	2
District of Columbia	8
Florida	2
Georgia	1
Idaho	3
Illinois	52
Indiana	22
Iowa	15
Kansas	10
Kentucky	3
Louisiana	6
Maine	3
Massachusetts	71
Michigan	36
Minnesota	20
Mississippi	3
Missouri	26
Montana	2
Nebraska	6
Nevada	3
New Hampshire	5
New Jersey	20
New Mexico	2
New York	91
North Carolina	2
North Dakota	5
Ohio	52
Oklahoma	1
Oregon	3
Pennsylvania	54
Rhode Island	8
South Carolina	2
South Dakota	4
Tennessee	7
Texas	9
Utah	6
Vermont	6
Virginia	4
Washington	8
West Virginia	4
Wisconsin	22
Australia	2
Canada	8
England	1
Germany	1
Italy	1
Mexico	1
New Brunswick	1
Nova Scotia	1
Philippine Islands	2
Total	675

INSTITUTIONS REPRESENTED.

	Members	
	1907	1908
Massachusetts Institute of Technology	21	37
University of Illinois	18	24
Ohio State University	20	22
University of Minnesota	14	20
University of Wisconsin	16	18
Purdue University	16	17
The Pennsylvania State College	10	16
Pratt Institute	5	15
Case School of Applied Science	11	14
Stevens Institute of Technology	6	12
Cornell University	10	11
Worcester Polytechnic Institute	11	11
Yale University	2	11
Columbia University	12	10
Michigan Agricultural College	3	10
University of Kansas	2	10
University of Michigan	9	10
Michigan College of Mines	9	9
Armour Institute of Technology	5	8
Brown University	6	8
University of Missouri	5	8
Harvard University	6	7
Iowa State College	6	7
Lehigh University	6	7
University of Washington	7	7
State University of Iowa	6	6
Union University	3	6
Alabama Polytechnic Institute	4	6
Carnegie Technical Schools	4	6
Tuft's College	3	6
University of Colorado	5	6
University of Nebraska	6	6
University of Vermont	4	6
Washington University	3	6
Agricultural and Mechanical College of Texas	5	5
Clarkson School of Technology	3	5
Cooper Union for the Advancement of Science	1	5
University of Cincinnati	5	5
University of Colorado	5	5
University of Pennsylvania	3	5
Colorado State Agricultural College	2	4
Leland Stanford Junior University	4	4
Polytechnic Institute of Brooklyn	4	4
Tulane University	4	4
University of North Dakota	2	4
University of West Virginia	4	4

	Members	
	1907	1908
Colorado School of Mines	3	3
Lewis Institute	1	3
McGill University	3	3
New York University	1	3
Rensselaer Polytechnic Institute	1	3
Rose Polytechnic Institute	3	3
Rutgers College	1	3
State University of Kentucky	1	3
Thayer School of Civil Engineering of Dartmouth College	3	3
University of Arkansas	3	3
University of California	3	3
University of Mississippi	3	3
University of Tennessee	2	3
University of Texas	3	3
Bradley Polytechnic Institute	2	2
Delaware College	1	2
Drexel Institute	2	2
George Washington University	2	2
International Correspondence Schools	2	2
Louisiana State University	1	2
Missouri School of Mines and Metallurgy	2	2
Montana College of Agriculture and Mechanic Arts	1	2
New Hampshire College of Agriculture and Mechanic Arts	1	2
Nevada State University	2	2
North Carolina College of Agriculture and Mechanic Arts	1	2
Northwestern University	1	2
South Dakota Agricultural College	2	2
Toronto School of Applied Science	3	2
University of Arizona	2	2
University of Florida	2	2
University of Idaho	0	2
University of Maine	1	2
University of Toronto	0	2
University of Utah	0	2
Virginia Polytechnic Institute	1	2
Alabama Girls' Industrial School	1	1
Bowdoin College	0	1
Bucknell University	1	1
Carnegie Institution	1	1
Clark College	0	1
Clemsen College	1	1
Cleveland High School	0	1
Colorado College	1	1
Cornell College	1	1
Denison University	0	1
Dorchester High School	1	1
Earlham College	1	1

	Members 1907	Members 1908
Franklin Union	0	1
Haverford College	1	1
James Millikin University	1	1
Kansas City High School	1	1
Kansas State Agricultural College	0	1
Lafayette College	1	1
Massachusetts Agricultural College	1	1
Milwaukee School of Trades	0	1
Miller M. L. School (Virginia)	0	1
New Mexico College of Agriculture and Mechanic Arts	0	1
North Georgia Agricultural College	1	1
North Dakota Agricultural College	1	1
Nova Scotia Technical College	0	1
Ohio Northern University	0	1
Ohio Wesleyan University	0	1
Oklahoma School of Mines and Metallurgy	0	1
Oregon Agricultural College	0	1
Philadelphia Central Manual Training High School	1	1
Princeton University	1	1
St. Louis McKinley High School	1	1
South Carolina Military Academy	1	1
State School of Mines of Utah	1	1
Swarthmore College	0	1
Throop Polytechnic Institute	1	1
United States Engineering School	0	1
University of Alabama	2	1
University College, Sheffield, England	1	1
University of Chicago	1	1
University of Idaho	0	1
University of Manitoba	1	1
University of Syracuse	1	1
University of the South	1	1
University of Pittsburg	0	1
University of North Carolina	0	1
University of South Dakota	1	1
University of Sydney	1	1
University of New Brunswick	0	1
University of New Mexico	0	1
University of Oregon	0	1
University of Washington	0	1
Vanderbilt University	1	1
Virginia Military Institute	0	1
Washington and Lee University	1	1
Western University of Pennsylvania	1	1
Wisconsin State Mining School	0	1

SUMMARY BY OCCUPATION.

Classification	Teachers			Practitioners		
	1906	1907	1908	1906	1907	1908
Architecture	3	3	4	1	0	0
Biology	2	2	2	0	0	0
Chemistry	3	8	12	2	2	2
Civil Engineering	82	102	130	22	34	36
Deans and Directors only	7	11	22	0	0	0
Drawing	16	16	27	0	0	0
Electrical Engineering	38	47	72	9	13	15
Journalists	0	0	0	0	9	11
Manual Training	8	4	4	0	0	0
Mathematics	36	38	56	1	2	1
Mechanical Engineering	69	81	112	17	18	19
Mechanics	13	15	23	0	0	0
Metallurgy	5	6	..	0	0	0
Mining Engineering	14	14	20	7	6	6
Physics	13	24	38	0	0	0
Presidents	20	15	22	0	0	1
Shopwork	3	10	12	0	0	0
Trade-school	1	5	5	0	0	0
Unclassified	9	8	14	14	10	9
Professors who are also Deans		(40)	(41)			
Total	342	409	575	73	94	100

GENERAL SUMMARY.

Different Institutions Represented.

	1906	1907	1908
Colleges and Universities teaching Engineering			
Domestic	85	94	116
Foreign	6	5	5
Manual Training, High, Correspondence, and Trade Schools	13	17	19
Total Institutions	104	116	140
Teachers, and, in many cases, also practitioners	342	409	575
Practitioners, not teaching	73	94	100
Total Members	415	503	675

DECEASED MEMBERS.

Name.	Year of Election.	Date of Death.	Memoir.	
			Vol.	Page.
William A. Anthony	1907	May 29, 1908.	XVI,	
George W. Atherton	1904	July 24, 1906.	XIV,	292
Volney G. Barbour	1894	June 4, 1901.	IX,	340
Charles B. Brush	1893	June 3, 1897.	VII,	181
Storm Bull	1893	November 18, 1907.	XVI,	
Eckley B. Coxe	1894	May 13, 1895.	VII,	182
Thomas M. Drown	1895	November 16, 1904.	XII,	244
Francis R. Fava, Jr.	1894	March 28, 1896.	VII,	183
Estevan A. Fuertes	1894	January 16, 1903.	XI,	372
Henry Fulton	1894	December 6, 1901.	X,	258
Herbert G. Geer	1894	March 7, 1900.	VIII,	371
Lyman Hall	1904	August 16, 1905.	XIV,	287
Albert H. Heller	1903	February 20, 1906.	XIV,	290
John B. Johnson	1893	June 23, 1902.	X,	259
Rodney G. Kimball	1894	April 25, 1900.	X,	261
Burton S. Lanphear	1897	October 14, 1904.	XII,	249
Benjamin F. La Rue	1899	December 22, 1903.	XII,	243
C. S. Magowan	1896	November 14, 1907.	XVI,	
Charles P. Matthews	1898	November 23, 1907.	XVI,	
Justus M. Silliman	1894	April 15, 1896.	VII,	184
James H. Stanwood	1894	May 24, 1896.	VII,	185
Robert H. Thurston	1893	October 25, 1903.	XII,	246
Alphonse N. Van Daell	1897	March 28, 1899.	VII,	186
John R. Wagner	1894	January 21, 1899.	VII,	187
Francis A. Walker	1896	January 5, 1897.	VII,	188
Howard S. Webb	1897	June 12, 1905.	XIV,	286
Nelson O. Whitney	1893	March 17, 1901.	IX,	339
James R. Willett	1896	May 9, 1907.	XV,	679
De Volson Wood	1893	June 27, 1897.	V,	325

PAST OFFICERS

Special Committee for Division E, Engineering Education, World's Engineering Congress, 1893

IRA O. BAKER, Chairman,
WM. R. HOAG, Secretary,
MORTIMER E. COOLEY,
HENRY T. EDDY, Vice-Chairman,
C. FRANK ALLEN, Sec'y, *pro tem.*,
SAMUEL W. STRATTON,
STORM BULL.*

PRESIDENTS

DE VOLSON WOOD,* 1893–4,
GEORGE F. SWAIN, 1894–5,
MANSFIELD MERRIMAN, 1895–6,
HENRY T. EDDY, 1896–7,
JOHN B. JOHNSON,* 1897–8,
THOS. C. MENDENHALL, 1898–9,
IRA O. BAKER, 1899–1900,
FRANK O. MARVIN, 1900–1,
ROBERT FLETCHER, 1901–2,
CALVIN M. WOODWARD, 1902–3,
C. FRANK ALLEN, 1903–4,
FRED W. McNAIR, 1904–5,
CHARLES L. CRANDALL, 1905–6,
DUGALD C. JACKSON, 1906–7,
CHARLES S. HOWE, 1907–8.

VICE-PRESIDENTS

SAMUEL B. CHRISTY, GEORGE F. SWAIN, 1893–4,
ROBERT H. THURSTON,* FRANK O. MARVIN, 1894–5,
FRANK O. MARVIN, CADY STALEY, 1895–6,
JOHN GALBRAITH, JOHN M. ORDWAY, 1896–7,
THOMAS C. MENDENHALL, HARRY W. TYLER, 1897–8,
C. FRANK ALLEN, HENRY W. SPANGLER, 1898–9,
ROBERT FLETCHER, CHARLES D. MARX, 1899–1900,
THOMAS GRAY,* ALBERT KINGSBURY, 1900–1,
STORM BULL,* CALVIN M. WOODWARD, 1901–2,
JOHN J. FLATHER, FRED W. McNAIR, 1902–3,
CHARLES L. CRANDALL, JAMES C. NAGLE, 1903–4,
CLEMENT R. JONES, ELWOOD MEAD, 1904–5,
WILLIAM T. MAGRUDER, JOHN P. JACKSON, 1905–6,
ROLLA C. CARPENTER, CHARLES S. HOWE, 1906–7,
CLARENCE A. WALDO, WILLIAM G. RAYMOND, 1907–8.

TREASURERS

STORM BULL,* 1893–5,
JOHN J. FLATHER, 1895–9,
CLARENCE A. WALDO, 1899–1902,
ARTHUR N. TALBOT, 1902–4,
FRED. P. SPALDING, 1904–6,
ANSON MARSTON, 1906–7.

SECRETARIES

JOHN B. JOHNSON,* 1893–5,
C. FRANK ALLEN, 1895–7,
ALBERT KINGSBURY, 1897–9,
EDGAR MARBURG, 1899–1900,
HENRY S. JACOBY, 1900–2,
CLARENCE A. WALDO, 1902–4,
MILO S. KETCHUM, 1904–6,
WILLIAM T. MAGRUDER, 1906–7.

---

* Deceased.

MEMBERS OF PREVIOUS COUNCILS

Terms of Office Expired in 1894.

M. E. Cooley,
H. T. Eddy,
W. F. M. Goss,
W. R. Hoag,
S. W. Robinson,
H. W. Spangler,
R. H. Thurston.*

Terms of Office Expired in 1895.

H. T. Bovey,
W. H. Burr,
O. H. Landreth,
Mansfield Merriman,
W. G. Raymond,
G. F. Swain,
De Volson Wood.*

Terms of Office Expired in 1896.

I. O. Baker,
Storm Bull,*
S. B. Christy,
John Galbraith,
J. B. Johnson,*
F. O. Marvin,
C. D. Marx.

Terms of Office Expired in 1897.

H. T. Eddy,
J. J. Flather,
J. P. Jackson,
Albert Kingsbury,
L. S. Randolph,
S. W. Robinson,
R. H. Thurston.*

Terms of Office Expired in 1898.

C. F. Allen,
C. L. Mees,
Mansfield Merriman,
J. M. Ordway,
W. G. Raymond,
Cady Staley,
R. S. Woodward.

Terms of Office Expired in 1899.

Arthur Beardsley,
Robert Fletcher,
John Galbraith,
William Kent,
T. C. Mendenhall,
W. H. Schuerman,
M. E. Wadsworth.

Terms of Office Expired in 1900.

Storm Bull,*
L. G. Carpenter,
Albert Kingsbury,
F. O. Marvin,
R. B. Owens,
R. L. Sackett,
R. H. Thurston.*

Terms of Office Expired in 1901.

T. M. Drown,*
M. A. Howe,
I. N. Hollis,
Gaetano Lanza,
P. C. Ricketts,
R. G. Thomas,
C. M. Woodward.

Terms of Office Expired in 1902.

Brown Ayres,
G. W. Bissell,
J. J. Flather,
W. T. Magruder,
F. W. McNair,
J. M. Porter,
A. J. Wood.

Terms of Office Expired in 1903.

C. F. Allen,
D. C. Jackson,
N. C. Ricker,
J. P. Brooks,
Edgar Marburg,
A. L. Williston,
J. C. Nagle.

Terms of Office Expired in 1904.

W. F. M. Goss,
Thomas Gray,*
D. C. Humphreys,
O. H. Landreth,
W. G. Raymond,
L. E. Reber,
L. S. Randolph.

Terms of Office Expired in 1905.

Wm. Esty,
H. S. Jacoby,
L. J. Johnson,
Elwood Mead,
Edward Orton, Jr.
W. M. Towle,
J. L. Van Ornum,

Terms of Office Expired in 1906.

John Galbraith,
Frederick P. Spalding,
Charles S. Howe,
Henry W. Spangler,
Herman K. Vedder.
Walter M. Riggs,
Fred. E. Turneaure,

Terms of Office Expired in 1907.

Thomas Gray,*
Louis E. Reber,
James C. Nagle,
Arthur N. Talbot,
Robert S. Woodward.
William G. Raymond,
Clarence A. Waldo,

Terms of Office Expired in 1908.

Victor C. Alderson,
Francis C. Caldwell,
Arthur H. Ford,
Henry S. Munroe,
Frederick W. Sperr.
H. P. Talbot,
A. L. Williston,

* Deceased.

CONSTITUTION

OF THE

Society for the Promotion of Engineering Education

1. NAME—This organization shall be called the SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

2. MEMBERS—Members of the Society shall be those persons who occupy or have occupied responsible positions in the work of engineering instruction, together with engineering practitioners and other persons interested in engineering education.

Honorary Members of the Society shall be such persons as may be recommended by unanimous vote of the Council after a letter ballot. In taking this ballot, the Secretary is directed to close the polls one month after the names of the candidates are sent out. Councilors not heard from will be counted in favor of the candidate. Honorary Members shall not have the right to vote, shall not be eligible to office, and shall not be required to pay any fees or dues.

Any Member not in arrears for dues may become a Life Member by paying Fifty Dollars into the Treasury of the Society at one time.

The name of each candidate for membership shall be proposed in writing to the Council by two members by whom he is personally known. Such name, if approved by the Council, shall be voted on by the Society at the annual meeting, a vote of three-fourths of those present being required to elect; or, during the period between annual meetings, an affirmative letter ballot of three-fourths of those members of the Council whose vote reaches the Secretary within one month from the time of sending out the name of the candidate shall elect. Such letter ballot elections shall be credited to the previous annual meeting and dues will date from that time.

3. OFFICERS—There shall be a President, two Vice-Presidents, a Secretary and a Treasurer, each to hold office for one year, or until their successors have been elected and have qualified. The Officers shall be elected by ballot of the Society at the annual meeting.

4. COUNCIL—The Council of this Society shall consist of twenty-one elective members, one-third of whom shall retire annually. The officers and the Past Presidents of the Society shall be members of the Council *ex-officiis*.

Any member of this Society shall be eligible to election to the Council, provided that not more than one elective member shall be from any one college.

Members of the Council shall be elected by ballot by the Society at its annual meeting.

The Council shall constitute a general executive body of the Society, pass on proposals for membership, elect candidates *ad interim*, attend to all business of the Society, receive and report on propositions for amendments to the constitution, and shall have power to fill temporary vacancies in the offices.

The President of the Society shall be Chairman of the Council, and the Secretary of the Society shall be Secretary of the Council and shall keep the minutes of its meetings and an accurate record of all its actions.

When votes taken by letter ballot of the Council shall be required all votes which reach the Secretary within one month from the time of sending out the ballots shall be counted, but votes reaching the Secretary later than the time here specified shall not be counted.

5. NOMINATING COMMITTEE—The Nominating Committee shall consist of the Past Presidents and the seven elective members of the Council retiring the following year, provided, however, that if, of this committee, the number in attendance at any meeting be less than five, the President shall make appointments so as to form a committee of five.

6. FEES AND DUES—The admission fee, which shall also include the first year's dues, shall be Three Dollars and Fifty Cents ($3.50), and the annual dues thereafter Three Dollars

and Fifty Cents ($3.50), payable at the time of the annual meeting. The fiscal year shall end with the opening of the first General Session of the Annual Meeting. Those in arrears more than one year shall not be entitled to vote, nor to receive copies of the Proceedings, and such members shall be notified thereof by the Secretary one month previous to the annual meeting. Any member who has been in arrears more than two years and duly notified by the Secretary, shall be dropped from the roll, until such arrearages are paid.

7. MEETINGS—There shall be a regular meeting occurring at the time and place of the meeting of the American Association for the Advancement of Science, or of some one of the Nation Engineering Societies, or otherwise as the Council may determine.

8. PUBLICATIONS—The Proceedings of the Society, and such papers or abstracts as may be approved by the Council, shall be published as soon as possible after each annual meeting.

9. AMENDMENTS—This Constitution may be amended by a two-thirds vote of those present at any regular meeting of the Society provided the Amendment shall have been approved by a two-thirds vote of the Council taken by letter ballot.

BY-LAWS OF THE SOCIETY AND RULES GOVERNING THE COUNCIL.

First. The Officers of the Society shall constitute a Committee to arrange for the annual meeting and to prepare a program for the same.

Second. The President, the Secretary and the Treasurer shall constitute an Executive Committee which shall have charge of all matters relating to the expenditure of money of the Society, the making of appropriations for Committees and other purposes, the making of contracts, the approval of bills, and also during the period between the meetings of the Council have charge of other business affairs of the Society.

Third. Expenditures of money may be made only in accordance with a definite appropriation or direct vote of the Executive Committee and bills shall not be paid by the Treasurer until they have been approved by all members of the Executive Committee.

Fourth. Reading of papers shall be limited to fifteen minutes each or to such other time as may be designated by the Program Committee, and abstracts of papers of about three hundred words shall be printed when practicable, and distributed in advance to the members.

Fifth. The time occupied by each person in the discussion of any paper shall not exceed five minutes.

Sixth. The President, the Secretary and the retiring Secretary shall constitute a Publication Committee, of which the Secretary shall be Chairman, to edit and have charge of the publication of the Proceedings of the Society. If at any time there be no retiring Secretary the retiring President shall be a member of this Committee.

Seventh. Additions or amendments may be made to these By-Laws on recommendation of the Council by a two-thirds affirmative vote at any regular meeting of the Society.

PUBLICATIONS.

The publications of the Society can be obtained from the Secretary. The current issues are distributed gratuitously to members in good standing. The price of the bound volumes of the Proceedings is $2.50 to non-members, $2.00 to public libraries, and $1.50 to members for their own libraries.

Reprints of papers may be ordered when the paper is in type form, and either with or without covers, at a price depending upon the number of pages and copies desired.

PROCEEDINGS.

DETROIT MEETING.

JUNE 24 TO JUNE 27, 1908.

The sixteenth annual meeting of the SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION was held in conjunction with the annual spring meeting of the American Society of Mechanical Engineers in Hotel Cadillac, Detroit, Michigan, during the week of June 22 to June 27, 1908, and was one of the most successful and most largely attended conventions the Society has ever held.

WEDNESDAY, JUNE 24.

AFTERNOON SESSION.

The meeting was called to order on Wednesday afternoon, June 24, with Vice-President William G. Raymond, dean of the College of Engineering of the State University of Iowa in the chair. The meeting was opened by an address of welcome from the mayor of the city of Detroit, and a response by the vice-president. The report of the secretary was then read and accepted and the report of the treasurer was read and was referred by the chairman to an auditing committee consisting of Professor Dugald

Library
N. C. State College

C. Jackson, Professor Landreth and Professor Hood. Following this Professor Dugald C. Jackson presented the Report of the Joint Committee on Engineering Education created at the meeting of 1907 by a resolution inviting the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers and the American Chemical Society, each to appoint two representatives to join with three representatives of the Society for the Promotion of Engineering Education in a thorough and comprehensive investigation of undergraduate and graduate courses of study leading to engineering, and the relation of these courses to the work of the engineering profession. At the close of the report the following resolutions were offered, seconded and carried.

Whereas, The time consumed in the formation and organization of the Joint Committee on Engineering Education has been greater than was expected, and

Whereas, The work of this committee can be greatly facilitated by cooperation with The Carnegie Foundation for the Advancement of Teaching and with the General Education Board, be it

Resolved, That the date for presentation of the final report of the Joint Committee on Engineering Education be coincident with that for holding the regular annual meeting of this Society in 1910, and be it further

Resolved, That the action of said committee in extending an invitation of membership to the president of the Carnegie Foundation for the Advancement of

Teaching and to the General Education Board be and hereby is approved. Also

Resolved, That the Joint Committee is authorized to print its preliminary report at once, if, in its judgment, so doing will advance the interests of its work.

The remainder of the afternoon session was devoted to the reading and discussion of the following papers: "The Course in English in Technical Schools," by Professor Telleen; "The Results of an Experiment in Teaching Freshman English," by Dean Kent; "A Proposed Course in General Engineering," by Harwood Frost, and "Present Curricula of the Mechanical Engineering Course," by Professor Magruder.

EVENING SESSION.

On Wednesday evening the Society listened to a most charming and inspiring lecture on "Contributions of Photography to our Knowledge of Stellar Evolution," given for its benefit and for the American Society of Mechanical Engineers in the auditorium of the Young Men's Christian Association by Professor John A. Brashear, manufacturer of lenses and astronomical instruments, scientist and educator, of Allegheny, Pa. The ladies were invited to attend this lecture and all greatly enjoyed both the talk and the beautiful photographs of the heavens and nebulous stars which were thrown upon the screen.

THURSDAY, JUNE 25.

MORNING SESSION.

On Thursday morning the members of the Society enjoyed a trip as guests of the president and general manager of the Great Lakes and Engineering Works to their shipyard at Ecorse to witness the launching of the 10,500-ton steamer "William B. Meachum." This launching was of special interest as it was the first time that many of the members, especially those from the East, had ever witnessed the "*sidewise*" launching of a vessel, as is the custom on the Great Lakes, as distinct from the usual "*end-on*" method which is customary on the Atlantic coast.

AFTERNOON SESSION.

The committee appointed to audit the Treasurer's report submitted the following report.

REPORT OF AUDITING COMMITTEE.

DETROIT, June 24, 1908.

SOCIETY FOR THE PROMOTION OF
ENGINEERING EDUCATION.

Gentlemen: Your Committee appointed to audit the accounts of the Treasurer for the past year respectfully report that they have examined the accounts and vouchers of the Treasurer and have found them to be correct as reported.

DUGALD C. JACKSON,
OLIN H. LANDRETH,
OZNI P. HOOD.

Upon motion the report of the Auditing Committee and the report of the Treasurer were adopted.

The vice-president, Dean Raymond, then took the chair while the Society listened to the presidential address, on "The Function of the Engineer in the Conservation of the Natural Resources of the Country," by President Charles S. Howe, President of the Case School of Applied Science. At the close of the address the following resolution was offered and carried:

Resolved, That the council be requested to consider and report to this convention the advisability of the appointment of a committee which shall bring to the attention of our membership for practical action the conservation of natural resources as so ably presented by President Howe's address.

The remainder of the session was devoted to the reading and the discussion of the following papers: "The Correlation of the Courses in Engineering Colleges," by Dean Anthony; "Adapting Means to the End in Technical Education," by Mr. Arthur L. Rice; "The Place of Foreign Languages in the School of Engineering," by Professor Wright; "Second Degrees for Graduates in Engineering Courses," by Dean Goss; and "Scholasticisms in Engineering Education," by Dean J. P. Jackson.

After the discussion of the papers it was moved that a committee of five be appointed by the executive committee to consider and report to the Society upon the practicability of simplifying the character of degrees conferred in engineering.

The motion was carried.

EVENING SESSION.

The members of the Society for the Promotion of Engineering Education attended as guests the annual spring reception of the American Society of Mechanical Engineers. This was the distinctively social feature of the meetings and was largely attended by the ladies who came as guests of the members. The reception and the dancing were held in the main dining hall on the second floor of the Hotel Cadillac.

Friday, June 25.

MORNING SESSION.

The following resolution was recommended by the Council and was adopted.

Resolved, That the widest possible circulation of papers read or presented to this Society is desirable; that in all cases it is proper for the secretary or the author of a paper to allow its publication at any time subsequent to its presentation, provided in every case due credit be given to this Society.

The Committee on the Revision of the Constitution reported through its chairman, Professor Arthur L. Williston, that the amendments to the constitution that had been recently submitted to the Council had been approved by it by letter ballot with a two thirds affirmative vote. After a short discussion it was moved and seconded that the report of the committee be accepted, and that the proposed constitution as recommended by the committee and by the Council be adopted. The motion was unanimously carried.

The remainder of the session was devoted to the reading and the discussion of the following papers: "Hydraulic Laboratories, Their Equipment, Method of Conducting Work, Their Efficiency as a Factor in Engineering Education, Methods of Teaching Hydraulics, Etc." by Professor Mead; "Electrical Laboratory Equipment and Efficiency," by Mr. Edmands; "Cement Laboratory Practice," by Professor Baker; "How Far is Pure Thermodynamics of Value in Preparing Students for Handling Mechanical Engineering or Heating Problems?" by Professor Wood; "On Entropy," by Professor Ennis; "The Use and Abuse of Lantern Slides," by Professor Norris; "The Concentric Method in Engineering Education," by Professor Karapetoff; and "Should an Engineer Be Required to Hold a License," by Professor Drane.

AFTERNOON AND EVENING.

The members, guests and ladies were invited by the Detroit Local Committee to a delightful afternoon and evening sail on the Detroit River. They left on the steamboat "Britannia" from the Detroit, Belle Isle and Windsor Ferry dock, at the foot of Woodward Avenue, sailed around Belle Isle, thence down the river to Amherstburg and to the head of Lake Erie. They returned by way of Bois Blanc Island where supper was served.

SATURDAY, JUNE 27.

MORNING SESSION.

The Committee on Industrial Education presented a report through its secretary, Professor Williston.

This was followed by the reading and the discussion of the following papers: "Two Years of the Cooperative Engineering Courses, University of Cincinnati," by Professor Schneider, and "The Careers of Graduates in Mechanical Engineering," by Professor Furman.

The Nominating Committee presented the following report.

REPORT OF THE NOMINATING COMMITTEE OF OFFICERS OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION FOR THE ENSUING YEAR 1908–1909.

For President: Frederick E. Turneaure, University of Wisconsin, Madison, Wis.

For First Vice-President: Mortimer E. Cooley, University of Michigan, Ann Arbor, Mich.

For Second Vice-President: Olin H. Landreth, Union University, Schenectady, New York.

For Secretary: Arthur L. Williston, Pratt Institute, Brooklyn, N. Y.

For Treasurer: William O. Wiley, 43 East 19th Street, New York City, N. Y.

For Members of Council to Serve Three Years: Lester P. Breckenridge, University of Illinois, Urbana, Ill.; Thomas Gray, Rose Polytechnic Insitute, Terre Haute, Ind.; Lewis J. Johnson, Harvard University, Cambridge, Mass.: William T. Magruder, Ohio State University, Columbus, Ohio; William G. Raymond, State University of Iowa, Iowa City, Iowa; Herman Schneider, University of Cincinnati, Cincinnati, Ohio; Clarence A. Waldo, Purdue University, Lafayette, Ind.

HENRY T. EDDY,
Chairman.

Upon motion the report of the committee was adopted and the secretary was instructed to cast the unanimous ballot of the Society for the gentlemen nominated, who were declared the duly elected officers of the Society for the ensuing year.

The Committee on Resolutions presented the following report.

REPORT OF COMMITTEE ON RESOLUTIONS.

The Society for the Promotion of Engineering Education, recognizing that much of the great pleasure and profit of the sixteenth annual meeting has been due to the courtesy of the American Society of Mechanical Engineers in arranging for a simultaneous meeting and for the participation of our Society in the very liberal entertainment so generously given by the citizens of Detroit, instructs its secretary to cordially thank the American Society of Mechanical Engineers for its courtesy and interest, and to thank the Local Committee of Arrangements, the Great Lakes Engineering Works, and the Detroit, Belle Isle and Windsor Ferry Company whose highly successful efforts to entertain both the Society and the accompanying ladies have been thoroughly appreciated.

WILLIAM G. RAYMOND,
ROBERT FLETCHER,
OZNI P. HOOD.

Upon motion the report of the Committee on Resolutions was adopted.

The president appointed to fill the vacancy on the Committee on Industrial Education, caused by the resignation of Professor Edgar Marburg, Walter B. Russell, Director of Franklin Union, Boston, Mass.

REPORT OF THE SECRETARY 1907–08.

To the Society for the Promotion of Engineering Education:

Your Secretary is glad to be able to report that the affairs of the Society are in a most flourishing condition. There never has been a period in our history, I think, when the interest in the work of the Society has been so active or so general, or when the confidence in its usefulness has been so strong.

The increase in our membership both last year and this year, bears generous testimony to these facts and to the growing importance of our work. The cordial and ready response which the Secretary has received from our members and the many expressions of appreciation of the importance of the Society as an influence in Engineering Education, and the willingness of the members generally to do their share of the work are all encouraging facts which point toward a bright future.

At the Ithaca meeting, two years ago, the Secretary reported 415 members. The last volume of the Proceedings shows 503 names on the list. Since July 1, 1907, 184 men have made application for membership. Of these, 94 have been elected to membership by letter ballots of the Council, taken on March 17 and April 28. The balance remain still to be acted on by the Council and the Society at the present meeting.

During the year nine resignations have been received and accepted as follows: Harold W. Brown, Irving A. Colby, Andrew E. Foyé, Frederick R. Hutton, Daniel E. Moran, Henry S. Pritchett, Arthur H. Timmerman, A. N. Johnson, Edson R. Wolcott.

And four times since we met a year ago death has entered our ranks. Charles Scott Magowan, professor of municipal and sanitary engineering, College of Applied Science, State University of Iowa, died on November 12, 1907. Storm Bull, professor of steam engineering, University of Wisconsin, died on November 18, 1907. Charles Philo Matthews, professor of electrical engineering and director of the electrical laboratory of Purdue University, died at Phœnix, Ariz., November 23, 1907. And recently, the Secretary has received notice of the death of Wm. A. Anthony, professor of physics and electricity and director of physical laboratories at Cooper Union for the Advancement of Science and Art.

There is little else which the Secretary needs to report at the present time. The file of new application blanks and the program for the present meeting constitute the principal report of the year's work. The program for the meeting a year ago was a very full one; partly by way of variety therefore, partly because of our joint convention with the American Society of Mechanical Engineers, and partly to recognize the fact that this is the fifteenth anniversary of the founding of the Society, it seemed wise to provide on the program a smaller number of formal papers and topics for discussion than usual, in order that our professional sessions might not be too fatiguing, and to introduce into the program a number of entertainment features which it is hoped will make this meeting one of special interest.

In closing, the Secretary wishes to thank all of the officers of the Society for the help and support that they have given him during the year in every possible way, and to express his appreciation of the cooperation of the entire membership. He also wishes to take this opportunity to place upon record his conviction, which has been strengthened by the year's experience, of the value and great worth of this Society to its individual membership and to the cause for which it stands.

The record of our professional sessions, printed in the fifteen volumes of our Proceedings is a most creditable one, and each year the value of our Proceedings is becoming greater; but more than this, to the individual members of the Society who have stayed with it and worked for it, year after year, experience has proven that the Society has been a broadening and a helpful influence, which has much more than repaid them for the interest and time and the money that it cost.

Arthur L. Williston,
Secretary.

Treasurer's Report, 1907–1908.

To the Society for the Promotion of Engineering Education:

The Treasurer would respectfully report to the Society the condition of its finances, as follows:

SUMMARY OF RECEIPTS.

Received from Professor A. Marston, retiring Treasurer, July 23, 1907	$1,496.27
Current dues, July 23, 1907, to June 15, 1908	1,458.00
Back dues	165.21
Sale of reprints to authors	29.49
Sale of Proceedings	112.90
Interest at bank and collections on checks	4.66
Total	$3,266.53

SUMMARY OF EXPENDITURES.

Programs and badges for Cleveland meeting	$ 28.37
Fire insurance on volumes of Proceedings	49.50
Reporting Cleveland meeting	121.80
For Committee on Statistics	24.25
Expenses of Retiring Secretary, January 1, 1907, to July 1, 1907	370.91
Expenses of Treasurer for stationery, postage and check collections	68.87
Expenses of Secretary for stationary and printing.	47.95
New Era Printing Company:	
For Volume XIV	598.12
For Lists of Members, Author's Reprints, Expressage, etc. (Volume XIV.)	281.07
For Volume XV., on account	1,000.00
Total expenditures	$2,590.84
Cash on hand, June 15, 1908	675.69
	$3,266.53

ASSETS.

Cash on hand	$ 675.69
Due for reprints, Proceedings and membership	512.85
Total	$1,188.54

LIABILITIES.

Balance due New Era Printing Company for printing Volume XV	$ 418.90

Due William T. Magruder, retiring secretary......	82.44
Due for printing, stenographic work, clerical help, stationary and postage.....................	311.26
	$ 812.60
Net surplus	375.94
	$1,188.54

The above statement of assets and liabilities does not include the amounts due the Society for author's reprints, etc., on Volume XV., which will probably amount to about $100, nor does it include the honorarium for the editor of Volume XV., or for the Secretary for 1907–1908.

It may be of interest to note that the total amount of unpaid dues still on the books of the Treasurer is $372. There are in all 86 members who owe $3 each, 7 members who owe $6 each, 4 members who owe $9 each, and 3 members who owe $12 each. The number of members who owe more than $3 at the present time is considerably smaller than the corresponding number a year ago. The number who owe but $3 is considerable greater, caused by the large number of new members who have been elected to the Society since January 1, 1908.

Respectfully submitted,

William O. Wiley,
Treasurer.

The following applicants were admitted to the Society between July 1, 1907, and July 1, 1908.

Elected by letter-ballot March 17, 1908; L. F. Adams, W. D. Appleton, T. W. Atkinson, G. M. Bacon, A. J. Becker, R. D. Bradbury, R. B. Brinsmade, J. J. Carty, A. N. Clark, E. H. Comstock, F. M. Comstock, C. H. Crouch, B. G. Fogg, H. C. Ford, C. E. Fuller, P. Gillespie, W. C. Hoad, W. G. Hornell, J. W. Howard, S. E. Hutton, A. C. Jewett, J. S. A. Johnson, W. A. Johnston, R. R. Lawrence, W. H. Lawrence,

C. N. Little, G. F. Loughlin, E. L. Lundgren, A. L. Merrill, G. E. Monroe, E. B. Norris, C. L. Norton, C. J. Norwood, A. A. Noyes, C. E. Paul, C. F. Perry, C. P. Poole, C. M. Pratt, F. B. Pratt, E. H. Rockwell, G. C. Shaad, A. Shane, R. O. Smith, A. Songe, G. W. Swett, E. T. Tannatt, A. L. Thomas, G. S. Thompson, F. M. Tisdel, S. Tompkins, E. A. Touceda, J. C. Tracy, B. E. Trask, F. H. Vose, E. L. Waterman, E. Wheeler, A. M. Wilson, V. T. Wilson, W. A. Yerzley. (59.)

Elected by letter-ballot April 28, 1908: L. L. Appleyard, F. E. Ayer, B. J. Dalton, H. V. Egbert, M. L. Enger, S. D. Fowler, R. W. Gay, N. R. George, Jr., C. O. Gunther, A. Haring, R. C. H. Heck, J. A. Holmes, W. L. Hooper, A. K. Hubbard, H. J. Hughes, C. W. Malcolm, A. L. McRae, D. P. Moreton, J. C. Ostrup, J. A. Polson, A. P. Poorman, C. H. Porter, H. A. Rice, N. C. Riggs, R. B. Slippy, A. W. Smith, T. J. Smull, Jr., C. A. Stone, E. A. Stone, P. F. Walker, E. S. Webster, G. V. Wendell, B. N. Wilson, A. S. Wright, C. M. Young. (35.)

Elected at Detroit Meeting: L. M. Arkley, J. T. Atwood, W. Babcock, A. Ball, W. A. Ballou, W. E. Barrows, Jr., O. H. Basquin, E. N. Bates, A. R. Bench, P. S. Biegler, S. L. Boothroyd, R. L. Brown, A. D. Butterfield, R. A. Chittenden, H. E. Cobb, A. W. Cole, G. A. Covell, H. G. Crane, F. A. Dalberg, C. E. DePuy, H. B. Dirks, H. B. Drowne, W. V. Dunkin, W. C. Ebaugh, J. W. Elliott, H. C. Enders, H. B. Evans, C. S. Farnham, W. H. P. Faunce, O. J. Ferguson, H. D. Frary, A. E. Frost, W. A. Garrison, C. B. Gibbons, C. F. Harding, G. A. Harter, F. M.

Hartmann, H. B. Hastings, H. L. Hodgkins, O. Hovda, C. E. Houghton, J. H. Hunt, L. D. Huntoon, E. L. Ingram, A. M. Kenyon, A. W. Klein, C. B. LePage, E. H. Lockwood, W. L. Lodge, C. A. Lory, R. R. Lyman, J. V. Martenis, R. C. Matthews, M. C. Maxwell, E. B. McCormick, D. W. Mead, W. A. Miller, R. Modjeski, J. H. Morecroft, B. L. Newkirk, J. D. Newton, E. W. Nichols, H. P. Noble, H. B. North, R. A. Porter, F. L. Pryor, A. Riesenberger, J. W. Roe, A. Rogers, R. Rogers, W. F. Schaphorst, H. L. Seaver, F. J. Seery, F. H. Sexton, S. C. Shipley, P. F. Smith, E. E. Sparks, E. F. Stevens, C. E. Stewart, E. R. Storm, J. M. Telleen, C. C. Thomas, E. Thomas, W. H. Timbie, O. F. von Voigtlander, W. B. Wendt, A. L. Westcott, L. P. Wheeler, D. A. Young. (90.)

This makes a total of 184 new members to be admitted to the Society during the year.

On motion the meeting adjourned *sine die.*

The records show that 103 persons were registered in attendance at the convention.

Respectfully submitted,

Arthur L. Williston,

Secretary.

ADDRESS OF WELCOME.

BY MAYOR THOMPSON.

of Detroit.

Mr. Chairman and Gentlemen of this Convention: It is a great pleasure to be here this afternoon—every mayor says that to you, I suppose, no matter what city you hold your conventions in. But I say it with sincerity, because it has been very seldom during my term of office that I have had the distinction of welcoming to our city such a distinguished delegation as you gentlemen represent. The city of Detroit entertains many conventions during the year. and we are always glad to have visitors come and see our beautiful city, because we think we have one of the finest cities in the world, and we like the people to know our city and talk about it. On behalf of the people of this city, I extend to you a hearty and a sincere welcome. We feel honored in having you gentlemen in our midst, and the city is proud to have you hold this convention here. We want you to enjoy yourselves, we want you to have a good time, and we know the country at large, the whole United States will be benefited by the results of this convention.

I had the pleasure, last evening, of welcoming the Mechanical Engineers here to our city and I said to them, as I am going to say to you, that the country now belongs to the engineering fraternity, or, I might say, to the teachers of the engineering fraternity.

We have fought our battles to peace; we have our Union; we have one flag. We have the masters of finance handling the financial interests of the country; we have the miner and the farmer attending to the natural resources, but it is now up to the engineers and the gentlemen that you educate to go on and ornament and develop this country. Fifty years ago no one could imagine what this day would bring forth, and I do not suppose anybody here present can imagine what fifty years from now will bring forth. With all the genius that you gentlemen have and exert on your pupils, we do not know what this world is coming to.

That the college engineer is the best, nobody can deny, and that the practical man would be far more advanced if he also had a college education, not only in the engineering line but in any other line. It was not my good fortune to have any college education, but I know its value in private life as well as in public life, and feel, very often, the necessity of such an education.

You gentlemen are doing a noble work. I imagine that many of you could get, perhaps, double or treble your salary if you used your efforts and genius in a practical way. But no! You have secluded or hidden yourselves in your universities to teach young America how to take advantage of the different inventions and ideas that you are teaching, and we are proud of you. You deserve great credit. They talk to you about war; they talk about the great generals; I want to say that you are the great generals in peace, because the development of this country depends upon the gentlemen that you are educating and training. Nothing is impossible in this day and generation, with the class of engineers that are being turned out in your colleges and universities. They annihilate space and time; they take unproductive material and, as if by magic, turn it into money, and several other things in that line. I am not familiar with your business, and am an ordinary layman speaking from the knowledge gleaned from the papers and what I read elsewhere.

We always say to visitors when they come to our city, we would like you to combine pleasure with business. We have some very fine mechanical institutions which we are proud of—our automobile factories. I have no doubt you have received invitations to participate in some of the functions during the week, the sinking a section of the tunnel tomorrow; the launching a ship; and we would be pleased to have you participate in any and all of the pleasures that our city can afford.

Again, on behalf of the people of the city, I extend to you a hearty and sincere welcome; I hope you will have a successful convention and I hope the results will be beneficial not only to Detroit but the whole United States. I thank you.

Dean Raymond: Your Honor, it is not often that the layman appreciates the teacher. We are, therefore, particularly grateful to you not only for your cordial welcome, but for your acknowledgment of the fact that the works of the engineers are the works of the teachers. We are modest; we do not claim them really as our own works; they are the works of our pupils, but we rejoice in them and are perfectly delighted when some one from the outside does give to us a little of the credit. We therefore are particularly grateful to you for this acknowledgment, and in behalf of the Society I beg to thank you for your cordial welcome to this city; it is a delightful city. On a previous occasion I had the pleasure of visiting it with the American Society of Civil Engineers, and I know something of its beauty; I shall know more about it now that I am able to accept of your hospitality.

THE FUNCTION OF THE ENGINEER IN THE CONSERVATION OF THE NATURAL RESOURCES OF THE COUNTRY.

BY PRESIDENT CHARLES S. HOWE,

Case School of Applied Science of Cleveland, Ohio.

The prosperity of a country depends primarily upon its natural resources. The raw material which the farmer and the manufacturer use and the products of which furnish business for the merchant come from or depend upon timber, fuel, minerals, soil, water. These are the natural resources of any country, and as they exist in large or small quantities, as they are easy of access, as their quality is good or bad, must depend the agricultural and industrial prosperity and success of the nation. Some countries have large supplies of one or more of these natural products and a few are blessed with them all. This country is especially fortunate in that it has within its bounds not only all of these natural resources, but that it had originally large quantities of each of them and that they were rich in quality and easy of access. When the country was first settled by Europeans, the new inhabitants gave little thought to the question of natural resources except in so far as these directly concerned their daily life. They established themselves where the soil was rich because they wished to pursue agriculture as a vocation, but they made no study of soils further than this. Forests were regarded as an encumbrance to be cleared away as soon as possible for they interfered with agriculture, which was the chief business, and they were the lurking places of wild beasts and wilder men. They were useful only for the purpose of furnishing lumber and fuel. A very small amount of forest on each farm was sufficient for these purposes and so the settler did not hesitate to cut down as much as he possibly could. The other natural resources he knew little or nothing about. It was many years before coal came into use and then only in those sections where it could be dug from the ground near at hand. Precious metals were unknown. The little iron that was used was brought from abroad. The waterways were used wherever possible and in many sections of the country they were the only avenues of travel, but the amount of commerce upon them was small. Under conditions such as these it was only natural for the inhabitants to suppose that the resources of the country were inexhaustible. They had all they could use and more, and if they had thought of the question of exhaustion, it would have seemed to them that all they had to do was to move to another section, north, south or west, and start over again. While they depended for their livelihood upon one of the natural resources, the soil, yet they were practically independent of most of the others. As the country developed and civilization increased their dependence upon the natural resources increased also, but at first in a scarcely perceptible way. This dependence has grown up to the present time, but it is still difficult to make people see the force of it. Most of the products which come from the natural resources of the country are used at a great distance from the raw material and hence it is difficult to make people see the connection between the two and to realize their dependence upon the latter. The natural resources have been so freely drawn upon and often so ruthlessly used that already along some lines they are beginning to disappear to an alarming degree. Investigation has shown that they are in great danger of exhaustion. This is a grave state of affairs and proper steps should be taken so far as possible to prevent it by preserving the natural resources that remain and by carefully and judiciously using them in the future. Unless we can prevent their absolute destruction the ruin of the nation is assured. We should aim to transmit to the generations which are to follow us a country which is better than the one we received from our ancestors and not one which is being rapidly depleted and impoverished. That this can be done has been shown by the work of scientific men during the past few years. Of course some of the natural resources cannot be replaced, but their rapid depletion can be stopped and they can be preserved for our use for many centuries. The soil should never be allowed to grow poor. It should grow richer as it is cultivated longer. The forests can be retained through planting at the same time that timber is being cut for use. Fuel and iron cannot be replaced but they can be carefully and economically used. The use of water either for navigation or power does not destroy the water and hence does not endanger the waterways system.

With the growth of civilization the wants of men multiply and hence greater demands are made upon nature, for the supply with which these wants are satisfied must come primarily from nature. This will cause a greater drain in the future than in the past. The use of the natural resources has made us a great nation and if we are to maintain our position among other nations we must be able to use these natural resources in the future, and even to draw upon them to a greater degree. This makes it absolutely essential that the wasteful methods now in use should cease and that a careful and systematic study of the use of the materials we now have be intelligently made. Our land is nearly all taken up. There is remaining in the possession of the government a comparatively small amount, excepting that which is useless for cultivation. Nearly all the forests have disappeared; in some sections entirely so and very little effort has been made to replace them. Our coal and iron are rapidly disappearing and will in time entirely disappear. Our waterways are injured and many of them are entirely useless for navigation or for power. The question of the conservation of our natural resources is, then, a serious one and deserves careful and mature deliberation. It would seem wise to use to the best advantage even those natural resources not in danger of exhaustion.

Conference at the White House.

On May 13, 14 and 15 there was held at the White House in Washington a conference on the conservation of the natural resources of the country. This conference gathered at the invitation of the President of the United States and was composed of the governors of the states with three delegates from each state appointed by the governor: of the members of the Cabinet, the judges of the Supreme Court, some of the members of Congress, and representatives from all the great engineering societies. As president of this Society I received an invitation and attended the conference. This meeting was one of the most notable ever held in the country. The President of the United States opened each session and presided at the first and last. At the opening session he delivered a strong address upon the question of conservation which is one that has received his earnest attention for many years. The governors of forty-four states were present. Many members of the Cabinet, of the Supreme Court and of both houses of Congress accepted the invitation and attended one or more of the sessions.

Addresses were made upon the subjects of forestry, fuel, mineral products, soil wastage, irrigation, and the waterways. Papers were read by Mr. Andrew Carnegie and Mr. James J. Hill, who have taken a great interest in the questions under consideration. Many of the governors and quite a number of the other delegates took part in the discussion. Every one present seemed to be impressed with the importance of the gathering. To many of the governors and their associates the subject seemed to be entirely new. It had never been directly presented to them and they had not of course understood its importance, but there was not a dissenting voice as to the neces-

Library
N. C. State College

sity of conserving our natural resources and making them serve the nation as long as possible. A number of the governors stated that upon their return home they would immediately appoint forestry and other commissions which would study these questions within the borders of their states, and that when these commissions made their reports they would do all in their power to carry out the recommendations.

The representatives of the scientific societies probably appreciated the condition of affairs and the momentous possibilities of the questions discussed better than any of the others, with perhaps the exception of the President. Some of them read papers and a number took part in the discussions. At the close of the session a statement of the present condition of affairs, and a recommendation as to the proper steps to be taken to conserve the natural resources were adopted as the sense of the convention.

The engineer adapts the forces of nature to the use of men and this adaptation should be done both economically and efficiently. It is not enough to show that a certain force can be made to work when a machine transforms raw material into finished product. The work must be done efficiently—that is to say, the greatest amount of good must come from a given expenditure of energy. This makes the machine efficient and shows that it is doing all that it is possible for it to do, and when this is the case it is generally considered that the engineer has successfully performed his duty. If it is a question of using the force or material in some other way, through some other kind of machine, then the engineer may also be concerned, and it may be necessary for him to change his methods of work to conform to a new demand—that is, of economy. In some cases the application of the force or the use of material is not economical for reasons which are beyond the power of the engineer to control for they may be economic in their character. In the future, waste of raw material should be abhorrent to the engineer and his aim should be to conserve the materials which nature has provided for his use. The agriculturist and the forester as well as the engineer are concerned in the conservation of the natural resources, but in a broad sense all may be considered as belonging to the same class. They all develop the natural resources of the country and prepare them for the use of men. I shall speak of these resources separately and try to show in what way the engineer, the forester and the agriculturist, may work for their conservation.

Forests.

I have already stated that in the early days of our history it was the one aim of the settler to destroy the forests because they were in his way. He was an agriculturist and needed to have his land cleared of trees and other obstructions in order that he might harvest the greatest crop. As the country grew the demand for lumber increased and then it became necessary to save the trees in the forest and turn them into lumber but the supply still seemed inexhaustible and only the finest and best of the trees were used. The destructive use of the forests thus begun has continued ever since, though perhaps not in so great a degree. It takes from thirty to seventy-five years to grow a tree, but the lumbermen only cut those which have grown the straightest and cleanest and only use the best parts of the tree that is cut. The branches and the upper part of the tree are left to decay in the forest. They are not only wasted but they are scattered over the ground in such a way as to prevent future growth, for the soil is covered with a mat of material through which it is hard for any living thing to penetrate. It is necessary to burn this over in order that a new growth can rapidly start. But the burning over of the land effectually kills the young trees which were growing among the old ones and thus entails a further loss upon the forest and its owner.

The demand for lumber has increased enormously during the past few years. In 1880 the consumption per capita in the United States was 360 feet, while in 1906 it was 440 feet. The total amount of lumber cut in 1906 was over 40,000,000,000 feet and this yearly amount will largely increase in the future, both through the increase in population and through the increase per capita unless some steps are taken to prevent it. No accurate census of the amount of timber in the country has been made but it is estimated that we have now of standing timber about fourteen hundred billion feet. We are using forty billion feet per year. Upon this basis the present lumber supply will last thirty-five years but this does not take account of the increase in the amount used per year, nor does it take into account the amount of timber which will grow during the next thirty-five years. If nothing is done to increase our forest area we may suppose that these two will balance each other although it is probable that the lumber cut will increase faster than the growth. But even the more conservative calculation shows that our forests cannot last more than thirty-five years on the present basis of cutting. Long before that time the cost of lumber will largely increase and at the end of that period there will be no timber fit to cut. When we consider the extent to which wood is used at the present time, how much it means to all men, this is a most serious question.

The government has tried to check this depletion of our forests by establishing forest reserves in different parts of the country. It is estimated that at present there are in forests about seven hundred million acres of which twenty per cent. are in national and state hands. This does not mean that all of this land is fully covered with forests, for large sections of it may be totally barren, but surrounded by forests in such a way that it is necessary to call the whole forest land, until a very accurate survey has been made. The National Bureau of Forestry of the United States Department of Agriculture and a number of state departments of forestry have done a great deal towards arousing public interest in the subject and establishing scientific methods of cultivation. Many of the state universities have established departments of forestry which are training foresters to take charge of the development of the forest interests of state and nation.

It is evident that in the future lumber must be considered as a crop to be planted and tended and harvested with the same care that other crops receive. It differs from them only in the methods of cultivation and the length of time necessary for its development. Under this scientific treatment trees will be planted on waste areas or other sections where ordinary crops are not profitable; they will be thinned out until only those which are likely to attain a mature growth are left, and they will be guarded against the destructive effect of forest fires. When a certain proportion of the crop is ready for harvesting the lumbermen will go in, cut the proper trees, carry away or burn the tops and branches and then the forester will plant new trees in place of those felled. In a few years another crop will be ready and the same treatment will be repeated. The older forests will be treated in a similar way except that the first stage of planting will not be necessary. In this way the forests will yield a regular crop of lumber once in so often. Under this treatment the forests become profitable to a very much greater degree than under the old method of cutting off all trees large enough for lumber at one time and practically destroying all the young growth.

In some European countries where this method of forestry is in use the entire public expenses of many townships are met by the sale of timber from the public forest lands. Our government reserves now yield but a very small income but in time as they are brought under the proper cultivation they will yield large results. As soon as forest planting is taken up on a large scale by national and state governments and by individuals the lumber question of the future will be settled. This process, however, is a slow one and we must expect that before that time comes the present forest reserves will be very largely exhausted. The danger, however, has been seen and the necessary methods for its correction have been developed. This has been the work of the scientific forester but the labor can only be done by those agencies which can supply the necessary funds.

The engineer is greatly interested in this question because he needs timber for many of his operations. He also has a hand in the conservation of our forest areas because of the use which he makes of steel and concrete in structural work. The amount of cement manufactured and used in the United States has increased each year until now it has reached vast proportions. It use will be greatly increased in the future especially in structural work, as we learn more and more about strength of concrete reinforced with steel. The United States government, engineering concerns and technical colleges are making an extensive study of this great engineering question and the results of their researches are put into practice as soon as they are published. Every engineer believes that the opportunity for this kind of investigation is very great and that it should be encouraged by both national and state governments.

FUEL.

Manufacturing industries depend upon fuel and cheap fuel is a vital element of our supremacy in the world's markets. The amount used at the present time in the United States is very large. In 1906 the coal mined amounted to four hundred million tons, having a value of five hundred and ten million dollars. The petroleum was valued at ninety million dollars; natural gas at fifty million dollars; coke at one hundred and ten million dollars and artificial gas at thirty million dollars. The total value of all fuels including by-products was almost one billion dollars.

Coal is found in almost every section of the United States, twenty-nine out of forty-six states having coal beds. Natural gas and petroleum are also found in many of the states. No matter how large the supply of these fuels may originally have been, a yearly drain such as just mentioned will inevitably in a few years sadly deplete it and the amount used is increasing every year and at a very rapid rate. But this is not all; the figures just given are those for the fuel taken from the ground and used, but the amount wasted doubles or trebles this total. Although this latter has not been put to any use, it has been destroyed so far as its future usefulness is concerned.

Natural gas is one of the most perfect fuels in existence. It is found under such pressure that it can be carried long distances and delivered in the factory ready for use. The turning of a cock regulates the supply and there is no dirt or loss. Many wells which yield small amounts are allowed to waste their supply in the air and it has frequently happened that the product of large wells is more or less wasted because proper piping is not at hand or proper precautions have not been taken. In many oil wells there is more or less gas and little if any effort is made to secure this supply. One geologist estimates that at least a billion cubic feet of gas per day are allowed to go to waste in the United States. Only one state, Indiana, has passed stringent laws against this waste. This state found that her supply of natural gas was rapidly being exhausted and that factories formerly dependent upon it were obliged to change to some other form of fuel. After a large part of the supply had been exhausted, laws were passed forbidding operators to open gas or oil wells until precautions had been taken to save all the gas.

The waste in coal mines is very great. Nearly every coal vein has streaks of sulphurous or bony coal mixed with the first-class material. This contains a large amount of carbon but is not as valuable as some parts of the seam; it is, therefore, left in piles inside the mine or dumped upon the culm bank on the outside. The amount of this low-grade coal varies from ten to fifty per cent. in every mine and under the present system of mining and of coal using this is an absolute loss. As the roofs of coal mines will not support themselves and as timber is expensive it is the custom to leave great pillars of coal in the mine as supports. As a rule these pillars are not taken out and so become absolute waste. In most coal mines there are several layers of the coal separated by shale formation. Some of these are narrow and cannot be mined to advantage; others are so broken up and dislocated by the mining of adjacent seams that it is impossible to take them out. All of these causes and perhaps some others make up a loss of from forty to seventy per cent. of the coal in the average coal mine of the country. As we obtain only thirty to sixty per cent. of the coal it is evident that we are exhausting our coal fields twice as fast as the actual amount of fuel used would indicate.

This immense drain upon the coal supply must very soon have an effect. It has been estimated that our anthracite coal cannot last more than seventy-five years. The bituminous coal will last much longer but it will become exhausted in those places where it is now used to the greatest extent. The most important coal vein in the United States is in the Pittsburg belt and is being more rapidly mined than any other. Each acre of land has supplied about eight thousand tons of coal and at this rate the state geologist of West Virginia estimates that at the beginning of the next century there will be no coal within one hundred miles of Pittsburg. No one can fail to perceive that this will be a terrible blow to the manufacturing industries of that great industrial center. In many sections of the country where neither anthracite nor bituminous coal are found large deposits of lignite exist. This lignite can be used for heating purposes in houses but is worthless for manufacturing purposes because the amount of ash is so great that it will not produce steam. In sections of country where this is the only fuel supply it is necessary to bring coal from long distances which makes it very expensive and puts a great tax upon manufacturing industries.

Our coal measures cover such an extensive area and the supply has seemed so great that the conservation of our fuels has received very little attention until within the past few years. 1903 the Technologic Branch of the United States Geological Survey was established in St. Louis in connection with the exposition and since then a very extensive study of the fuel supplies of the country has been carried on. Dr. Holmes, the director of this branch, Professor Lord, of the Ohio State University, in charge of the chemical work, Professor Breckenridge, of the University of Illinois, in charge of the boiler tests, and Professor Fernald, of Case School of Applied Science, in charge of the gas producer and gas engine tests, are all members of this society. The results obtained by these men, all of them engineers, has been of an astonishing character. It has been found that the fine coal, the refuse of mines and breakers, hitherto regarded as of little value and sold at an extremely low price, can be made into briquettes at a comparatively low cost and it is then as valuable as the finest coal that can be obtained. It has also been found that many non-coking coals can, by proper methods, be coked as readily as the best coking coals of Pennsylvania. These two results alone are worth many times as much as this bureau has cost the government, for certain manufacturing industries must have coke for fuel and in some sections it has been necessary to bring the coke from long distances because no coking coal was at hand although large supplies of other coal were easily obtainable.

But perhaps the most wonderful results from these experiments have come through the investigations in regard to the use of coal in the gas producer and the gas engine. With the old processes we do not obtain on the average more than five per cent. of the heat value of our coals. The steam engine utilizes from four to ten per cent. but the gas producer and the gas engine utilizes from eleven to eighteen per cent. Coal converted into gas produces then two and one half times as much power as when burned under a boiler. The best Pocahontas coal under a boiler was found to produce .28 H.P. per pound of coal per hour, while with a gas producer the same amount of coal produced .96 H.P. or 3.34 times as much as when used in the ordinary way. A lignite which would produce only .01 H.P. per pound of coal per hour when used under a boiler produced .35 H.P. when used in a gas producer. A still more interesting fact is that the best Pocahontas coal used under a boiler produced .28 H.P. per pound per hour while a lignite in a producer gave .30 H.P. Thus, lignite turned into gas gave more power than the best coal when used under a boiler. These results indicate that there is fuel in almost every part of the United States which can be used to produce power through the gas producer and gas engine, so that the amount of valuable fuel for power purposes has been increased many fold by the work of the Technologic Branch.

It is true that these results while they show a great improvement over ordinary methods look small compared to what should theoretically be obtained. Even the gas engine under the most favorable conditions does not utilize over eighteen per cent. of the heat value of the coal. There is still a great opportunity for the scientific man and the engineer to devise methods by which a larger per cent. of the energy of our fuels can be utilized. And the engineer has an important work to do in connection with the results already obtained. The gas engine has been in use in Europe for a number of years and is now being introduced into this country. There are installations where the horse power runs into thousands but these are isolated and are principally in connection with steel plants. The average manufacturer hesitates to install a gas engine because he fears that he cannot depend upon it every day as he can upon the steam engine and because he knows that it cannot be operated by the same engineer who can operate his steam plant. The steam engine is so simple and has been in use so long that it is very easy to make repairs upon it and it does not take long comparatively to train a man to use it. The gas engine is more complicated, is not as well understood and at present there are very few men who are experienced in its use. The greater initial cost of the gas plant, the cost of operating and the feeling which the manufacturer has that it is unreliable will retard its use but if our mechanical engineers and especially our engineering colleges will make the thorough study of this question which it deserves, there is no doubt that within a few years the gas engine will practically supplant the steam engine. The manufacturer wants power and he wants it as cheaply as it can possibly be obtained. If a new form of prime mover will develop two and one half times as much power as the old without too much initial cost or expense of maintenance, the manufacturer will rapidly install the new form. I believe our engineering colleges should install gas plants and make a thorough and systematic study of their use from day to day. In this way their faults can be remedied and through published reports the manufacturer can be made to feel that they are reliable. At the same time it will be of immense benefit to the students in the mechanical engineering departments to have a thorough training in the principles and the use of this new form of engine.

IRON AND STEEL.

This is an iron age. A nation's industrial progress is determined by the amount of iron ore it uses. Gold, silver, tin, lead and many other metals, while useful, could be dispensed with, but iron and copper are indispensable at this stage of the world's progress and of these two iron is by far the most necessary and the most useful. In 1907 fifty-three million tons of iron ore were mined and up to the present time seven hundred and fifty million tons have been mined in this country. The total amount of iron ore available in the United States is about as follows. In Lake Superior one billion five hundred million tons; in the southern district two billion five hundred million tons; in the other parts of the United States five billion tons; or a total of about ten billion tons. The highest grade is found in the Lake Superior district and hence this ore is in the greatest demand. In 1907 forty-four million tons were mined in this region and with the present increase in consumption the supply will be completely exhausted by 1940 unless new deposits are discovered. Up to the present time one thirteenth of the original supply of iron ore in the United States has been used. At the present rate of exhaustion the total amount of iron ore in the whole country will be used up before the end of the present century. This includes however only that supply which is of a high enough grade to be worked at the present time. After that it will be necessary to use lower grades of ore or we must do what so many European countries do—import from other places. This, of course, would be a great blow to our material prosperity. We have held our position in the industrial markets for iron and steel products on account of the abundance of our iron and coal and the consequent cheap price of both. When it becomes necessary to import either coal or iron, the cost of manufacture will largely increase and unless conditions are different from those at present, we shall no longer be an exporting nation. It will be necessary for the engineer to use all of his ingenuity and skill to avert the commercial and industrial disaster which will inevitably come when the supply of iron ore is exhausted. This may be done perhaps by new methods which will make it possible to use a lower grade of ore and yet obtain the manufactured product at the same price as at present. New alloys of iron will undoubtedly be discovered by the engineer which will make it possible to obtain the present strength for machines and structures with the use of less material, thus decreasing the amount of ore used. As concrete reinforced by steel takes the place of steel structures, a still greater saving in iron will be the result. This is inevitably coming for the progress in this direction during the past few years has been astonishing. The engineer is deeply concerned with methods of transportation and by substituting water transportation for rail transportation the saving in steel is very great for the same load can be carried by the former with one third the steel in the original plant that is necessary when loads are carried by rail.

RECLAMATION OF LAND.

The problem of maintaining the fertility of the soil and of enriching the worn out farming lands of the country is one which belongs to the scientific agriculturist and not to the engineer but there is one question connected with the agricultural interests of the country with which the engineer is vitally concerned—that is the reclamation of the arid and swampy regions. When the population of a country is sparse people seek the richest farming lands. They use the most exhaustive and least scientific methods of agriculture and the soil is soon depleted, but they are indifferent to this because there are large areas not in use and they can move from the worn-out farm to a new section. But as population increases the richest lands are rapidly absorbed, those of second and third grade must then be used and in the end all the fertile soil of the country is under cultivation. After this if population is to grow, more scientific methods of agriculture must be adopted or the hitherto useless land must be converted into fertile areas. The useless land consists of mountainous, desert and swampy regions. As a rule the mountainous districts are not available for agriculture though they may be for forestry. The desert land can in many cases be reclaimed by irrigation and the swampy land may often be reclaimed by drainage. Both of these processes, irrigation and drainage, are essentially within the province of the engineer and it is due to his efforts that so much fertile soil has been added to our national domain. Eight million acres have already been irrigated and in the next twenty-five years it is estimated that twelve million acres more may be reclaimed. We have in the United States eighty million acres of swamp land of which twelve million have already been drained and twenty million more may be drained in the future. This will enable us to raise a food supply for many millions of people and hence population can grow to this extent. But the problem of reclamation is only a part of the greater problem of the food supply of the nation and this does not belong to the engineer.

Inland Waterways.

The forests, water power, irrigation and inland navigation are more or less connected. The cutting away of the forests has been the cause of severe floods during certain sections of the year and very low water in the streams during the rest of the year. This has been detrimental to navigation and to the successful use of water power. Some streams are available both for irrigation and water power and it is a question which of these is of the greatest value. If the water in a stream is used for irrigation it cannot be used for power and hence only one of these methods of utilization is available. Some streams can be used for power and also for navigation. The water which is used for power is not destroyed but is turned back into the stream after its energy of motion or position has been used. The dams and other works necessary for the utilization of power form an impediment to navigation but can be overcome by canals. Thus it seems that the question of the use of water must be studied from several standpoints and the final solution of the problem will depend upon a number of considerations.

The United States possesses an unrivaled natural system of water ways. Professor Johnson says that at present we have 25,000 miles of navigable streams and there is as much more that can be made navigable. There are 1,410 miles of navigable waters in the great lakes and we have 2,120 miles of canals. There are 2,500 miles of waterways in sounds, bays and bayous on the Atlantic and Gulf coasts. These can all be made into a splendid inland system by the construction of a comparatively few miles of canals. On account of the absence of these canals only a very small part of this natural water route is at present utilized. In view of the importance of our waterways very little has so far been done for their preservation and use. We have wasted our natural routes of travel by the destruction of forests, by allowing our streams to fill up with sand, and by our neglect to use those which are still available. It is much cheaper to transport heavy material by water than by rail and the great advantage which comes from the proper use of waterways is shown wherever the government has given the necessary aid. The most striking evidence of the value of work properly directed is seen in the great lakes where a hundred million dollars has been spent. The water in the lakes is deep enough for the largest vessels but the rivers and straits connecting them naturally had only from eight to twelve feet of depth. This has been increased through government appropriations to twenty-one feet and now this body of great lakes forms one of the grandest pieces of navigable water known in the world. In 1889 twenty-five million tons passed through this system and in 1906 this had increased to seventy-six million tons. In 1907 it was eighty-three million tons and the increase will undoubtedly go on. In the Mississippi valley two hundred and eight million dollars have been spent but very little of it has gone for navigation. The larger part has been spent in jetties, dikes and so forth, necessary to prevent the loss of property and of life. So little has been done for navigation in the greater part of the Mississippi valley that the tonnage has decreased during the past twenty years. The inland waterways commission has done a most valuable work in showing the possibilities of our navigable streams, lakes and bays. It is to be hoped that Congress will make the appropriations necessary to make this body permanent and that its recommendations will receive favorable consideration. In England, France and Germany the waterways have received far greater attention than here. Although these countries are much smaller than the United States a very much larger proportion of the total tonnage passes through the rivers and canals. We should take a lesson from these nations and learn to give this subject the proper amount of attention. The larger use of our waterways will not decrease the amount of railway traffic. The railways now have more than they can do and they have found great difficulty in raising money sufficient to increase their trackage and their transportation facilities.

Railroad transportation can only take place over a pathway which has been especially prepared and which has been laid with steel rails. Water transportation does not need this. A natural pathway has been prepared and it is only necessary to improve this at a few points and to provide the vessels to carry the traffic. This makes the cost of transportation by water very much less than that by land. The initial cost is less and the cost of maintenance is less. If these streams can be given the proper depth so that larger vessels can be used and greater loads carried the transportation by water will be greatly increased. The whole question of water transportation belongs to the engineer. Whatever has been done in the past has been planned and carried out by him and all improvements in the future must be his work.

Conclusions.

I have presented in a very imperfect way the present state of our natural resources and have suggested some of the steps which should be taken to conserve them. There is nothing original in this. The facts have been gathered from government reports and papers written by experts in each of the several divisions of this question. The point which I had in mind during the preparation of the paper and to which I wish to give especial emphasis is that this work of conservation is the work of the engineer. I am inclined to think that in some cases the statements in regard to the destruction of our natural resources have been overdrawn and that they will not be totally exhausted in as short a period as some seem to believe, but there is no doubt that the question is a grave one and that it should be faced before it is too late. We should try to avoid waste and unnecessary destruction and we should also try to make the best possible use of all of our resources. It will be the work of the engineer to accomplish both of these objects, and it will also be his province to determine new ways of accomplishing results now so wastefully performed. In the past the engineer has been concerned with getting results. If the results were obtained, the waste and destruction of the natural product has scarcely been considered but in the future economy of the natural product as well as economy in the final result must receive careful attention. I believe the engineers of the country are capable of solving these problems and that if they are given the necessary governmental and private aid, the problem of the conservation of our natural resources will be solved.

The engineering colleges of the country will also have a share in this work. They are training the engineers of the future and from now on they must train them with this problem in view. They must not only give them the principles of engineering practice but they must show them how the work of the engineer can be carried out with a view of transmitting to our posterity the natural resources in, so far as possible, an unimpaired condition. As has been pointed out in the paper the conservation of some of our natural resources must be accomplished through new inventions. This means that the engineer of the future must be able to do more than the ordinary engineering work which comes to him from day to day. He must be so thoroughly trained in the principles of science and applied mechanics that he will be able to discover new processes and accomplish old results in new and more economical ways. He must be taught more thoroughly than ever before how to unite theoretical and practical knowledge. In short he must be able to think along scientific and engineering lines. This is the most difficult thing which the engineering college has to teach. There are so many subjects in the curriculum, so much that is necessary for the engineer to learn that he has not had the proper time to digest the material presented. I feel convinced that this problem of teaching the student to think, of giving him the power to solve things for himself has for many years received the earnest attention of the members of this society but in view of the problem which I am discussing to-day, I wish to urge upon all who teach in our colleges the importance of giving it still more attention. Engineering science is progressive, the subjects taught in our engineering schools are alive and not dead. We shall grow not only in knowledge but in methods, and we shall accomplish the results we ought to accomplish and solve the problems presented to us.

Present success in industrial methods is desirable and necessary but the engineer will deserve and will receive the grateful praise of coming generations if he transmits to them, as far as possible, unimpaired, the natural resources which have made us and will make them, a great nation.

PRELIMINARY REPORT OF THE JOINT COMMITTEE ON ENGINEERING EDUCATION.

At the last annual convention of this Society the retiring president introduced resolutions which were adopted by the Society, and which invited the leading national societies in the engineering branches to cooperate in the appointment of a Joint Committee to study engineering education. The resolutions invited each of the several societies to appoint two members of a Joint Committee, while this Society should itself appoint three members. The resolutions (which are printed on pp. 17 and 18 of the last volume of the PROCEEDINGS of this Society) point out the desirability of making a comprehensive study of the objects and the utilities and the correct ideals of engineering education and lay upon the Joint Committee the duty of examining into, ''all branches of engineering education, including research, graduate professional courses, undergraduate engineering instruction, and the proper relations of engineering schools to the secondary industrial schools or foremen's schools.'' And the resolutions further lay upon the Joint Committee the duty of formulating a report or reports, ''upon the appropriate scope of engineering education and the degree of cooperation and unity that may be advantageously arranged between the various engineering schools.'' The resolutions also require a preliminary report at this meeting.

When the resolutions were adopted it was hoped that the joint committee might be promptly formed and that its final report might be made within two years, but such a degree of cooperation between these societies had never before been secured and it was soon found that an extended period would be consumed in forming the committee. The somewhat onerous duty of bringing the committee to life was promptly laid by President Howe upon the author of the resolutions, who thereupon took up the duties of temporary secretary while the committee was in process of formation.

The resolutions were adopted on the last day of our convention held during the first days of July, 1907, and the governing boards of the professional societies invited to participate ordinarily have no meetings during the months of July and August. It was later found that certain societies were not able to act through their governing boards and the appointments of certain members of the Joint Committee were therefore delayed until after the opening of the year 1908. One of the societies involved held its meeting at which the members were appointed toward the latter part of December, 1907, and the last members were appointed during March, 1908.

The societies invited by the resolutions to join in appointing this Joint Committee are the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers, and the American Chemical Society, from each of which societies two members have been designated to act on the Joint Committee; and the Society for the Promotion of Engineering Education has appointed three members.

The oldest and most comprehensive of these societies is the American Society of Civil Engineers and its representatives on the Joint Committee consist of two eminent past-presidents, one of whom is chairman of that Society's Committee on Engineering Education. The American Society of Mechanical Engineers appointed two very distinguished members: one a past-president, Mr. Frederick W. Taylor, and the other Dr. Alexander C. Humphreys, president of Stevens Institute of Technology. Two past-presidents who are men of great distinction in the mining and metallurgical fields were designated on behalf of the American Institute of Mining Engineers: Professor Henry M. Howe and Mr. John Hays Hammond. Two past-presidents were likewise appointed by the American Institute of Electrical Engineers: the recently retiring president, Professor Samuel Sheldon, of the Polytechnic Institute of Brooklyn, and Mr. Charles F. Scott, who was most prominent in formulating the plan which resulted in the gift of a million and a half dollars for the building for the engineering societies of New York. Mr. Scott is a member of the special Educational Committee of the Society which he represents. The American Chemical Society appointed two men who take an untiring interest in educational affairs: Professor Henry P. Talbot, of the Massachusetts Institute of Technology and Mr. Clifford Richardson, of New York. The Society for the Promotion of Engineering Education appointed Professor C. L. Crandall, of Cornell University, Professor James M. White, of the University of Illinois, and Professor Dugald C. Jackson, of the Massachusetts Institute of Technology.

The resolutions for the appointment of this Joint Committee seem to have been particularly timely. Considerable discussion of the merits and demerits of engineering education has recently been running through the engineering fraternity and it has entered into the meetings of the professional engineering societies. The best friends of the engineering schools have exhibited a good deal of discontent with the results accomplished,—vaguely expressed discontent, to be sure, but only to be met by a positive and frank effort to find means for improvement. The American Society of Civil Engineers appointed a special committee to study the problems of engineering education at its last annual convention held in July, 1907, at the City of Mexico. This committee was appointed as the result of a letter ballot of all the members of the society, which was taken in response to resolutions introduced at the annual convention held a year earlier. The American Institute of Electrical Engineers passed resolutions at its annual convention of 1907 proposing the appointment of a committee to study electrical engineering education, almost simultaneously with the convention of the Society for the Promotion of Engineering Education; and various members of the American Chemical Society and the American Society of Mechanical Engineers were discussing and urging the appointment of similar committees by their societies. It is obvious that a Joint Committee representing all the aspects of engineering can be much more serviceable to engineering education and can make a much more valuable and authoritative report than would be possible for a committee viewing only a single branch of the subject, and that the various committees of circumscribed view might perhaps make reports based on insufficient study, and the net results might be without much advantage to the cause at heart. The now fully formed Joint Committee will have the prestige behind it of all five of the great engineering societies and will have the advantage of viewing the subject from every aspect in the several branches of the profession. It will also enjoy the aid of the special committee of the several societies.

Two members of the Joint Committee are also members of the special committee on Engineering Education of the American Society of Civil Engineers, one being chairman of that committee; and two other members of the Joint Committee are members of the special Education Committee of the American Institute of Electrical Engineers. Other members of the Joint Committee have been looked up to in their respective societies as representing the best views on education and have been the centers of the agitation for the appointment of committees on education. It is manifest that the joint committee represents the best educational impulses of each of the professional societies.

It is interesting and useful to look at the personnel of the committee which has now been organized with Mr. Desmond FitzGerald as Chairman and Dr. Samuel Sheldon as Secretary.

Mr. Desmond FitzGerald was educated at Philips Academy, Andover, Mass. He has had a distinguished practice as an hydraulic engineer. He was president of the American Society of Civil Engineers for the term of 1899–1900. His interest and contact with engineering education is indicated by his appointment to the chairmanship of the special committee on engineering education recently established by that society and by the fact that he is a life member of the corporation of the Massachusetts Institute of Technology. His distinction as an engineer and the fact that he is chairman of the committee on engineering education of the old and distinguished American Society of Civil Engineers make it particularly fitting that he should be chairman of the Joint Committee. His residence is Brookline, Mass.

Mr. B. M. Harrod, who is Mr. FitzGerald's colleague from the American Society of Civil Engineers, graduated from Harvard College in 1856. He was president of the American Society of Civil Engineers in the term of 1897–8, and has been a member of the Mississippi River Commission since 1879. He was a member of the Isthmian Canal Commission of 1904. Mr. Harrod is notably interested in the improvement of engineering education. He is a member of the special committee on engineering education of the American Society of Civil Engineers. His residence is New Orleans, La.

Mr. Frederick W. Taylor prepared for college at Phillips-Exeter Academy and ultimately entered Stevens Institute of Technology from which he graduated in 1883. He is doubtless the leading expert of the country on the subject of manufacturing organization. He is the inventor of the Taylor-White process of treating modern high-speed tool steels, for which he was personally decorated with a gold medal at the Paris Exposition of 1900. He was president of the American Society of Mechanical Engineers for the term of 1905–1906 and during that time had conferred upon him the degree of doctor of science from the University of Pennsylvania as a recognition of his distinction as a mechanical engineer. His presidential address "On the Art of Cutting Metals" is a monument to experimental research and scientific inventiveness in a very complex and difficult subject. Mr. Taylor's keen interest in engineering education is indicated by various papers and discussions. His residence is Philadelphia.

President Alexander C. Humphreys, of Stevens Institute of Technology, graduated in 1881 from the institute of which he is now president, and became one of the most distinguished gas engineers of the country. He is the author of many technical papers and since becoming the president of Stevens Institute of Technology in 1902 has given particular attention to improving the methods of engineering education.

Professor Henry M. Howe, one of the members of the American Institute of Mining Engineers designated a member of the Joint Committee, graduated from Harvard College in 1869 and from the Massachusetts Institute of Technology in 1871. He is a consulting metallurgist and is professor of metallurgy in Columbia University. He was president of the American Institute of Mining Engineers for the term 1893–1894. He is a metallurgist of great distinction and a notable author on metallurgy.

Mr. John Hays Hammond, of New York, Professor

Howe's colleague from the American Institute of Mining Engineers, graduated from Sheffield Scientific School in 1876, and later pursued a mining course at the Royal School of Mines, Freiburg, Saxony. He has been called upon to examine mining properties in all parts of the world. He was mining engineer and expert in South Africa for Mr. Cecil Rhodes. He is recognized as a leading mining engineer and has also given attention to engineering education as a patron of the Sheffield Scientific School.

Mr. Charles F. Scott, of Pittsburg, is a well-known electrical engineer, author of many important articles on electrical engineering subjects, and a successful inventor. He graduated from the Ohio State University in the arts course and he continued in graduate study at Johns Hopkins University. He is now consulting electrical engineer for the Westinghouse Electric and Manufacturing Co. He was president of the American Institute of Electrical Engineers for the term 1902–1903 and during his term of office the magnificent project of the Engineering Societies Building in New York was put on foot. Mr. Scott is a member of the special committee on education of the American Institute of Electrical Engineers.

Mr. Scott's colleague from the American Institute of Electrical Engineers is Dr. Samuel Sheldon who graduated from Middlebury College in 1883 and obtained his doctor's degree in Wurtzburg, Germany, in 1888. He is professor of physics and electrical engineering at the Polytechnic Institute of Brooklyn, and was president of the American Institute of Electrical Engineers for the term of 1906–1907.

Mr. Clifford Richardson, nominated by the American Chemical Society graduated from Harvard University in 1877, and has since been continuously in commercial chemical employment. At the present time he is the proprietor of the New York Testing Laboratory. He is the author of articles of importance on chemical manufactures and has been active in matters relating to the education of chemists and chemical engineers.

His colleague from the American Chemical Society is Professor Henry P. Talbot, the well-known professor of inorganic and analytical chemistry and head of the department of chemistry and chemical engineering at the Massachusetts Institute of Technology. Professor Talbot graduated from the Massachusetts Institute of Technology in 1885 and received his doctor's degree from the University of Leipsic in 1890. He is the author of various publications on chemical subjects and has deep interest in the development of chemical and engineering education.

Professor C. L. Crandall, representing the Society for the Promotion of Engineering Education, is one of the oldest professors of civil engineering. He graduated from the civil engineering course at Cornell University in 1872 and most of the time since then he has been a teacher in the department of civil engineering at that university. He is the author of various publications that are well known to students of civil engineering. He was president of the Society for the Promotion of Engineering Education for the term of 1905–1906.

Professor James M. White, one of Professor Crandall's colleagues from the Society for the Promotion of Engineering Education, is professor of architectural engineering at the University of Illinois. He has been acting dean of the engineering school at the University of Illinois, and has studied the problem of engineering education from the point of view of the administrator.

The third member appointed to the Joint Committee by the Society for the Promotion of Engineering Education is Professor Dugald C. Jackson, who has been temporary secretary of the Joint Committee. He is professor of electrical engineering at the Massachusetts Institute of Technology and was president of this Society for the term of 1906–1907.

The importance which is attached by the membership of the engineering societies to a full study of engineering education for the purpose of bringing it to its fullest fruition is indicated by the fact that no subject has heretofore held sufficient interest to gain the adhesion of all of these societies in a single joint committee. Also, as illustrating the fact that the leading men in the engineering profession are now coming to give much attention to the problems related to engineering education, it is impressive to observe that all the members of the Joint Committee appointed by the five invited societies are mentioned in the book known as "Who's Who in America," and a number of them are named in the compilation called "American Men of Science." Of the thirteen members of the committee, nearly one half have received the degree of doctor of science or doctor of philosophy. Three members are graduates of Harvard

University; two are graduates of the Massachusetts Institute of Technology; three or more spent a period of graduate study in foreign engineering schools or universities; two members are graduates of or have spent a period of graduate study at Cornell University; and two are graduates of Stevens Institute of Technology. A graduate of Sheffield Scientific School, a graduate of Ohio State University, a graduate of the University of Illinois, and a graduate of Pennsylvania State College complete the representation of the various engineering schools whose graduates compose members of the committee. The committee includes one member of the faculty of the University of Illinois, one of Cornell University, one of Columbia University, one of the Polytechnic Institute of Brooklyn and two of Massachusetts Institute of Technology besides the President of Stevens Institute of Technology.

A number of the members of the Joint Committee appointed by the professional engineering societies are in the faculties of engineering schools, in addition to the three members appointed by the Society for the Promotion of Engineering Education, but in these instances the men are also consulting engineers or advisors in engineering matters. Several other members of the committee are counted among the most distinguished practising engineers in their respective branches. A balance is thus obtained in the membership which promises a remarkably thorough study of the important questions which lie in the province of the committee and augurs well for an influential report.

The committee has not yet held a formal meeting, but the temporary secretary carried on a large amount of correspondence with the individual members besides consulting personally with those members who were within reach, and the organization of the committee was effected thereby. Mr. Desmond FitzGerald and Dr. Samuel Sheldon were elected permanent chairman and permanent secretary of the committee by letter ballot. The members of the committee have also considered (and expressed their views in regard to) the best method of procedure for the committee, and the belief is generally expressed that a careful study of statistics relating to engineering education is needed as a foundation for the work which the committee must do. These statistics are, for the most part, yet to be gathered, and for this reason it was suggested that the interest of the Carnegie Foundation for the Advancement of Teaching and the General Education Board should be enlisted. These bodies are in touch with the collegiate educational movements of the country and have statistics already in hand besides having suitable vehicles for gathering additional statistics. It was decided by the members of the committee to invite President Henry S. Pritchett, of the Carnegie Foundation for the Advancement of Teaching, to become a member of the joint committee and also to invite the General Education Board to appoint one of its members to a membership in the committee. This action has been duly taken by the committee and President Pritchett has already expressed his willingness to cooperate. We herewith request that this Society approve this action of the committee.

In carrying out the work of the committee it has been proposed to hold a series of conferences to include the most notable teachers in the various branches related to engineering as well as those not engaged in teaching and irrespective of whether they hold membership in the committee or not. This would be following a plan somewhat like that which was fruitfully used some years ago by the Committee of Ten on secondary education, appointed by the National Educational Association. In each of these conferences a member of the joint committee would be expected to serve as chairman. Subjects submitted to the different conferences would include physics, mathematics, applied mechanics, humanistic subjects, and various professional subjects. This arrangement should direct the best minds upon the details of the field to be studied by the joint committee and reports made from the conferences to the joint committee should give the latter an opportunity to analyze, correlate and utilize in its own report such recommendations of the various conferences as are found desirable to introduce. The question of how to pay the expenses of this procedure has not yet been solved.

Certain other important matters which could be wisely considered in such conferences are: the character of preparation most desirable in a student about to enter an engineering course; the extent to which humanistic (so-called general or cultural studies) may be advantageously carried on before and in connection with the course in the engineering school; what are the proper relations between young graduates and their employers, with special reference to the responsibility of the engineering school for affording a training which makes efficient men, and of the responsibility of employers for the exercise of discretion in their dealings with graduates during the early years of their employment; a consideration of the faults of the average young men who graduate from the engineering schools with a view toward recommending changes in the curricula which will tend toward a correction of these faults. The responsibilities of the engineering schools towards the progress of industrial education referred to in the president's address last year and also other aspects of the problems before the committee might be likewise dealt with fruitfully in such conferences.

The general opinion of the members of the committee indicates that at least two more years will be required to carry the study to a satisfactory conclusion. Meetings of the committee will be called at the earliest practicable moment and the work carried on as rapidly as the conditions will permit.

Samuel Sheldon,
Secretary.
Dugald C. Jackson,
Temporary Secretary.

THE COURSES IN ENGLISH IN OUR TECHNICAL SCHOOLS.

BY J. MARTIN TELLEN,

Assistant Professor of English, Case School of Applied Science.

Last September an entrance examination brought forth the confession from a high school student that his attitude toward English was due to his regarding the subject as being "feminine." This case is largely typical of the kind of students we deal with in our freshman work. In his preparatory training he shirks the general courses in behalf of the science courses. The result in college is easily imagined. The tendency of the student is so to concern himself with the mechanical, the materialistic, to merge himself with the purely technical, as to consider himself above all the endeavors of the teacher of English. This condition in our work is responsible for the yearly crop of articles written by prominent engineers on the deplorable manner in which the members of their profession express themselves. Between these two fires, the foolish prejudices of the immature undergraduates and the just criticisms of the experienced engineers, stands the teacher of English. It is, therefore, not surprising to hear one whose experience in a technical school is now of the past make the following statement in a recent book: "It is a wholesome experience for a literary man to have to serve his time in a technical school, where the students are all for Science and the Crafts and regard

Literature and Language as species of refined, purgatorial requirements.''

The status of the course in English in our technical schools is largely determined by the particular school considered. Comparative data would be of little real value due to the many limiting circumstances. However, certain widely different policies are worth noting. A few schools offer no English instruction, as rigid entrance examinations are supposed to exclude those who are incapable of expressing themselves in satisfactory composition, and as any lapse into incorrect English will be reduced to a minimum by the perusal of text-books and the contact with teachers, while the few probable cases of persistent violation of correct expression will be overcome by faculty cooperation. In several of the more prominent of these schools, plans have been projected to lengthen the course by requiring from two to four years of preliminary college training. Faculty cooperation, a plan which does away with a special English department and calls upon the teachers of all departments to enforce correct composition and expression, has not been widely enough adopted to warrant particular attention, though there has been no dearth of advocates of the system. In the large majority of technical schools of which a department of English is a part, we note a great divergence of equipment and of courses. Some are most deplorably equipped; others have a large and efficient corps of teachers, who have ample opportunity to realize their purpose. Some offer only one or two hours in freshman composition; others require composition work in the freshman and sophomore years, offer obligatory and optional courses in literature, and maintain a superintendence over the juniors and seniors in their technical composition work. The blame for the insufficient equipment of many of our schools is placed on the divergent ideals of the several schools, which prevent uniformity in such courses, on the rapid growth of most schools, which has necessarily caused a neglect in certain phases of the work, on the press of technical work, which has already produced overburdened schedules. So, to present a plan for universal adoption would be folly. The real question is, how under the conditions existing in each institution can the course in English be made efficient.

It falls to the lot of the teacher of English to solve this question. He has no ruts of tradition to guide him in his course. In most cases he is a pioneer. He must be in sympathy with the ideals of his school. In his relations with his students he must be resourceful and tactful. No particular degree, whether technical or academic, is a guarantee of the best training for this post. Were I to give broadly the necessary qualifications, I would name three: a thorough knowledge of the essentials of composition, a wholesome appreciation of literature, and the ability to teach.

The problem the teacher meets with in his students is a perplexing one. You are familiar with the lamentations to which our brother instructors in academic institutions give utterance when they contemplate the preparatory training in English of their freshmen.

But when you consider our freshmen, who in most cases have not taken kindly to languages and literature, as previously referred to, you see that we in the technical schools are well justified in joining their chorus of lamentation.

The first requisite in dealing with these students is to enlist their interest in the work. Here the words of the engineer come not amiss. Harrington, Wardlaw, Johnson, Ennis, and Scott are a few whose plea I have found effective. Their arguments are that the ability to express oneself correctly, clearly, and concisely has a pecuniary value, develops the power of initiative, of constructing, of composing—the real work of the engineer in all branches of his work—gives him the ability and facility of communicating his valuable experiences to his fellows, an opportunity which many fail to seize, as they realize their lack of training for such expression. The import of the work once brought home, their interest should be sustained by adapting the course to their present and future needs.

A factor which determines very largely the kind of course the teachers can give is the number of hours assigned them by the makers of the curriculum. If but a few hours are assigned in the freshman year, the work must be devoted wholly to composition. The larger number of hours assigned, the more literature can be given. However, those features of an English course which tend to make it most efficient are not recognized by the hours on the schedule. I refer to personal conferences with all students taking English, special courses for deficient students, and the active cooperation of all departments with the department of English. In a few of our schools the value of these features has been proved; in others they figure in the catalog, but not in actual practice.

The department of English finds its justification in its purpose, which should be the same as that of the school itself. Several recent writers have spoken of this as being threefold: general or cultural, scientific, and technical or engineering. All three of these purposes can be furthered by the English courses. To do this the teacher must impress upon his students the essentials of composition, train them in clear and concise expression in writing and in speaking, correlate as far as possible his work with that of the other departments, and finally, cultivate and develop the student's taste for literature.

Composition demands the power of initiative. It requires not only the assembling, but the mastering of material. Etymologically the word implies the work of the mechanic, where the framework, the outline, requires an arrangement and modifications which are nicely determined by the particular object the builder may have in view.

An important feature of composition work is illustrated by the experience of one of my students. Last summer while employed in a large railroad shop, he was called upon to prepare a report on the cost of handling certain pieces of car equipment. Very conscientiously he submitted a detailed report expressed in several well-written paragraphs. The superintendent called him to task for presenting so cumbersome a report and then kindly picked out the essentials, which were put into a table. In the latter form the entire content was evident at a glance, where formerly it was to be had at the expense of considerable time. Both were compositions, but the purpose for which the report was intended commended the table of figures as being far superior to a composition in the generally accepted paragraph form.

To encourage expression the teacher finds it feasible to assign subjects in which the students are particularly interested—problems of undergraduate interest, local political questions, technical topics, questions suggested by the required reading course in literature. Timely subjects of interest afford as pertinent problems to solve in composition and as excellent a drill in expression as do those subjects which require research work in encyclopedias and other reference books of the library. While a knowledge of reference books is to be encouraged, it should not be done at the expense of the student's interest in theme work. Again, whenever any feature of composition is discussed in class and the teacher wishes to have its import brought home, it is well to embody it in a theme subject. Among the subjects the speaker has used might be mentioned: "The Essentials of Technical Composition," "The Relative Merits of Diagrams and Photographs," "The Value of a Bibliography," "The Use of the Card System," "My System of Note Taking," and "The Qualities of a Good Speech."

If talks are required, and class-room experience has taught me their value, the principles voiced by Honorable Balfour in a recent address to the students of the University of Edinborough should be insisted on. The gist of his ideas is that the art of public speaking is simply the art of public conversation raised to a higher level.

The subjects just referred to have already brought us to the third purpose of the English course—to correlate the work with that of the other departments. Taking notes, writing shop reports, making speeches, constructing bibliographies are valuable aids to the student in all his work. The constructing of bibliographies should acquaint him not only with the general bibliographies, such as "Poole's," "The A. L. A.," "The Reader's Guide," but with the specially scientific and technical, such as "The Engineering Index," "Science Abstracts."

Personally, I believe that argumentation and debate should be included in the English course. In mathematics the student receives ample drill, it seems, in pure argumentation. However, he is not acquainted with formal logic and its application in debate. Then in his recitations, lectures, and society meetings he frequently has discussed the comparative value of processes, machines, etc. This affords the teacher excellent material for the selection of propositions from which technical briefs can be drawn up. The future advantage in argumentative work to technical salesmen, managers, and superintendents is quite evident.

The valuable aid rendered by the courses in modern languages is too obvious to need detailed mention.

The fourth and final purpose of the English course is to instil and cultivate in the student a love for literature. It is this feature of the English department where we notice the greatest divergence of opinions and of methods. In some schools no literature is taught; in others it is taught by recitations or lectures, or by both; in some schools it is incorporated with the composition work; in others reading lists are resorted to. These methods are not divorced from each other, for we find every possible combination; in fact in a few schools all of these methods are used. It is a noteworthy fact that the elective courses in literature are as a rule well patronized. Of all the students eligible to these courses, one of our schools reports an enrollment of seventy per cent. in the sophomore year and thirty-eight per cent. in the junior; a second, thirty-three to fifty per cent. in all the upper classes.

In selecting books for the literature courses the teacher must give evidence of considerable discretion. Should poetry be included; if so, to what extent? Should writers of belles-lettres monopolize the whole course? Should scientific and technical writers be included? What attention should be given Ruskin, Morris, Fiske, and others who have considered science and technical works in their broader aspects? In spite of the best intention of the teacher he necessarily runs a risk of selecting books which prove a benefit to one student and a bane to another. However, each book should have a substantial merit, to which the student's attention should be called.

Furthermore, the selection of literature and the teaching based on it should have the purpose of indicating that the study of literature does not carry with it the memorizing of the editor's notes; that poetry is neither doggerel nor the average magazine verse; that all history is not a series of paragraphs, in which the unpronounceable names and the refractory dates are the most prominent features; that all scientists and technical men have not dealt wholly in class-room facts and theories; and, that the biographies of our great inventors and other scientists afford as inspiring interest as do our "best sellers." In other words, the teacher must endeavor to root out prejudices, which, unfortunately, are too commonly found in his freshmen. Those poets should be selected who have given an appreciation of life which readily appeals to the undergraduate. The time and effort necessary to appreciate Milton's art and conception of life is better expended on Shakespeare. And this principle applies to the majority of writers found in the literature courses of the academic curriculum.

Such a course in literature should be conducted as personally as possible. The student should have the option of and the aid in choosing those books, the nature of which will particularly appeal to him. As I said before, the object should be to instil and cultivate, for some students have not passed, in fact never will pass, through the A, B, C's of literature appreciation, while others who take naturally to reading, whose reading has already been extensive should be encouraged to read more intensively.

From what has been said it will be inferred that the speaker is in favor of a literature course. The reasons why he would urge the general adoption of such courses are that the study of literature aids composition work, affords a form of recreation, which is the natural component of his technical education, and acquaints him with that common heritage of mankind, for which Huxley in his several essays on education has frequently made eloquent pleas. On one occasion he said: "I am the last person to question the importance of genuine literary training, or to suppose that intellectual culture can be complete without it. An exclusively scientific training will bring about a mental twist as surely as an exclusively literary training." And it would be an easy task to produce statements of our prominent engineers of to-day to support this contention of Huxley's.

In this indication of the fourfold purpose of the courses in English—to enforce the essentials of composition, to train the students in correct expression, to correlate the work with that of other departments, and to develop an appreciation of literature—it will be seen that I firmly believe the work should be practical. As Mr. Benson says in his "From a College Window": "My own theory is a simple one, I think we ought first of all to equip the students, as far as we can, to play a useful part in the world. . . . The further task that lies before us educators, when we have trained a mind to be useful, consists in the awakening, in whatever region may be possible, of the soul. By this I do not mean the ethical soul, but the spirit of fine perception of beauty, of generous admiration of what is noble and true and high."

Finally, what is needed in the English work in our technical schools?

In the first place, more individual work with the students, both in composition work and in the study of literature. While I have unjustly placed too much emphasis on a certain narrow-minded type found in our technical schools, I have passed by our goodly share of students who for a logical and clear presentation of a subject, for a keen appreciation of literature vie favorably with their fellows in academic institutions. Neither class is to be neglected. To be obliged to treat all the students as a single unit is an imposition on both student and teacher. When we bear in mind that each subject in composition involves certain problems to be solved, we feel justified in saying that such work requires as much indididual attention as does descriptive geometry. The marginal corrections cannot command the attention of the student that do the spoken criticism and counsel of the teacher.

Then in the case of literature study, I believe that personal discussions of the books assigned for home reading will prove more satisfactory than will written examinations. Such examinations call for either answers that test the student's knowledge of the contents or appreciations of the book as a whole. The first plan defeats the real purpose of literature study; the second produces too frequently a generalized appreciation couched in the commonest and most inexpressive adjectives. Knowing the taste of the student, the teacher is enabled not only to learn how the books have been read and with what degree of wholesome interest, but to offer such criticism as the individual student needs. A fortunate reply to this proposal is found in the fact that in many of our schools the department of English is being increased so as to make possible more individual work. However, in the great majority of cases, the English work is handicapped by the many recitations hours required of the teacher and the excessive amount of theme correction expected of him. Well defined policies as to the amount of work for each teacher are evident in many quarters. In one institution three sections consisting each of about thirty men, each section meeting twice a week, are assigned to one instructor. A table of statistics of the equipment of the English courses would reveal why our technical graduates too commonly leave college with their notorious inability to meet the requirements in expression demanded of them.

The second and final need that I would emphasize is that of the hearty and active cooperation of all departments with that of English. Several of our western universities have adopted rules, which oblige any student who submits any written work deficient in correct expression to receive further instruction in English. Many of our teachers of science subtract from the grade for misspelled scientific words, while others "mark down for such bad handwriting and such gross violations of the rules of English composition as may interfere with clearness and definiteness of expression." Then there are the special courses for upper classmen who have been found deficient in correct expression by the teachers of the several departments. In Massachusetts Institute of Technology this course has an enrollment of from three to twenty members. If a premium be placed on clear, concise, and correct expression throughout the entire college course, the educators will not need to apologize for this neglected phase of the graduate's training.

In conclusion, I would say that our technical schools are alive to the situation. Every year we notice decided improvements. One institution is dividing the classes into sections according to the student's ability in the use of English. The same institution announces that a technical graduate has been added to its corps of instructors. Another scientific school is having erected a new building, in which, it seems, the floor given over to the department of English has been so arranged as to facilitate personal conference work. These are only a few of this year's innovations which go to prove conclusively that the English work in engineering schools is keeping abreast of technical education, as the opportunity for such advancement is made possible.

Note.—This paper was discussed with the following paper (see pages 84–97).

RESULTS OF AN EXPERIMENT IN TEACHING FRESHMAN ENGLISH.

BY WILLIAM KENT,

Late Dean of the College of Applied Science, Syracuse University.

It is a common complaint in engineering colleges that students entering the freshman class have, on the average, no better knowledge of how to write an ordinary English composition than they might be expected to have on entering the high school four years earlier. It is therefore necessary to teach in the college the kind of English composition that should have been taught in the high school.

Two questions arise in regard to the teaching of English in the college: (1) How should the subject be taught? (2) How can the efficiency of the teaching be measured? In discussing the first question with Professor R. C. Congdon, head of the English department in the College of Applied Science, Syracuse University, a year ago, the writer stated his ideas on the subject about as follows: That the whole time given to English in the freshman year should be devoted to teaching common English composition of the kind that an engineer would be called upon to write in his everyday practice; that the subject matter of a student's composition should be within the range of this own knowledge; that particular attention should be paid to spelling, to punctuation, to paragraphing, to grammar and rhetoric, and that in style of diction the one thing to be aimed at was clearness. Also, that the art of literary criticism of one's own compositions should be taught by having the students criticise the work of their fellow students.

In regard to the second question, how can the efficiency of the teaching be measured, the writer's idea was expressed in a memorandum handed to Professor Congdon a year ago, from which the following is quoted:

"*First Exercise for the Class in Freshman English.*—Have each student write in class a 400-word essay on the subject: 'Why does the average student hate English?' Explain that the subject is given first, to get the freshman's ideas on the subject; and, second, to get an idea of the ability of each student to write good English composition on a subject with which he is familiar. State that grading will be done, not on the ideas, but on the other merits of the essay, including neatness, penmanship, punctuation, spelling, grammar, rhetoric, logic and style. The style to be aimed at is that of a clear and dignified newspaper or magazine article.

"*Second Exercise.*—A week later, before grading, hand the essay of each man to the next man in the class, in alphabetical order, and ask him to criticise it for spelling, punctuation, grammar and rhetoric, making critical marks where he finds errors, to make on a separate piece of paper a list of the words misspelled, and to copy what he considers the worst sentence from a rhetorical point of view.

"*Second Trial.*—Hold these compositions until the end of the year. In May, ask the students to write a new composition on 'Freshman English. In what way does it differ from High School English?

Changes I would suggest in the methods of teaching High School English.' Have the new compositions criticised in the same way as the first set, and make a statistical comparison of the two sets.''

In August, 1907, I wrote some additional suggestions to Professor Congdon, from which I quote:

''In the second exercise, when the students criticise the work of their fellows, I would ask them to grade the papers on the basis of ten for each of the following points: (1) penmanship; (2) spelling; (3) punctuation and capitalization; (4) grammar and rhetoric; (5) general excellence of the argument and method of treatment of the subject; making fifty points in all. One point should be deducted for each error in spelling, punctuation and capitalization; the other points being graded on a scale of ten according to the student's own idea of grading.

''At the next meeting of the section the papers should each be handed to the next man in alphabetical order, and he should go over the work of the first man to find whether he had made any mistakes or omissions. He should also pick out what he considers the worst sentence, or if he agrees with the first man, then pick out what he considers the second worst sentence. The two grading reports on each paper should be averaged and the results tabulated. The instructors might then take the papers and select from them the twenty per cent. having the lowest marks, for the purpose of critical study, and the five per cent. having the highest marks, which might possibly serve as models of good composition. The reports of the students' criticism of the worst sentences should then be gone over, and all those sentences which the instructors thought especially bad should be mimeographed and furnished to the students for further exercises.

"A similar work should be done on the papers written near the end of the year, and the average grading at the beginning and end of the year compared to show the improvement, if any. A list of all the words misspelled in the two sets of papers should be made, with the number of times each word had been found misspelled. This will show what improvement had been made in spelling and also what words are most persistently misspelled. These words might be printed for use as a spelling book for the next year's class."

The suggestions quoted above were adopted by Professor Congdon, with a few slight modifications, and the results, which show a most gratifying success, are given in a report by him, as follows:

In an attempt to test the comparative ability to write English, of students entering English (I.), L. C. Smith College of Applied Science, Syracuse University, and of those finishing the course, themes were required to be written on a given subject in September, 1907, and in June, 1908; these themes were corrected according to a prescribed method, and the resulting grades were averaged and compared.

Each of these themes was corrected twice by different students and the results were averaged. To render the test more valuable, ten sets of two papers each, written by the same students at the beginning and at the end of the year respectively, but selected entirely at random, were graded carefully by Professor Congdon, according to the method prescribed for student correction, and the results were averaged with those obtained by the students. The themes were from 500 to 800 words in length; were written in the class-room without help or previous announcement; the time allowed was two hours. At the beginning of the year, the subject assigned was, "My Impressions of Syracuse University," at the end of the year, "My Impressions of Syracuse University at the End of My Freshman Year."

In correction, ten per cent. was allowed for penmanship and appearance of theme, twenty per cent for sentence structure, twenty per cent. for spelling, twenty per cent. for punctuation and capitalization, and thirty per cent. for general excellence of thought and treatment. Five mistakes in spelling, or ten in punctuation and capitalization, were enough to take away all credit of these points. Of the one hundred and thirty men who began the work in English (I.), seventy-nine remained until the end of the year. The work of the fifty-one who did not remain was not considered.

The percentages showing improvement in the grades of themes as wholes, in spelling, and in punctuation and capitalization, are given below. In considering these grades, it should be remembered that the students were much more severe critics at the end of the year than at the beginning, and that the first themes were written as part of an examination while the second themes were not.

AVERAGE GRADES OF THEMES AS WHOLES.

	September, 1907.	June, 1908.
Marked by students	75.8 per cent.	81.0 per cent.
Marked by Professor Congdon	62.5 "	86.2 "

AVERAGE GRADES IN SPELLING, FIVE MISSPELLED WORDS GIVING ZERO.

	September, 1907.	June, 1908.
Marked by students	44.8 per cent.	82.7 per cent.
Marked by Professor Congdon	52.0 “	86.0 “

AVERAGE GRADES IN PUNCTUATION AND CAPITALIZATION, TEN MISTAKES GIVING ZERO.

	September, 1907.	June, 1908.
Marked by students	66.5 per cent.	78.7 per cent.
Marked by Professor Congdon	59.2 “	83.3 “

AVERAGE OF ALL MARKS.

	September, 1907.	June, 1908.	Percentage of Improvement.
Themes as wholes	69.3 per cent.	83.6 per cent.	20 per cent.
Spelling	48.4 “	84.3 “	74 “
Punctuation and capitalization	62.8 “	81.0 “	29 “

The following table gives the original satistical report, from which the above table is a summary:

ENGLISH I.—L. C. SMITH COLLEGE OF APPLIED SCIENCE.

Results of comparisons made between work done in September, 1907, and June, 1908, respectively.

Books marked by students. Each marked twice and the results averaged.

Professor Congdon's Sections.

Students remaining throughout year, 43.			Students present part of year, 23.
September, 1907.	June. 1908.		September, 1907.
74.3 %	82.6 %	Average standing.	68 %
113	32	Misspelled words.	74
73 %	87.4 %	Punctuation and capitalization.	69 %

Mr. Baebenroth's Sections.

Students remaining to end of year, 36.			Students present part of year, 28 .
September, 1907.	June, 1908.		September, 1907.
77.3 %	79.4 %	Average standing.	74.4 %
105	37	Misspelled words.	149
60 %	70 %	Punctuation and capitalization.	61.7 %

Average of Books Graded by Students.

Students remaining throughout year, 79.			Students present part of year, 51.
September, 1907.	June, 1908.		September, 1907.
75.8 %	81 %	Average standing.	71.2 %
218	69	Misspelled words.	223
2.76	0.87	Do.—average per student.	4.37
66.5 %	78.7 %	Punctuation and capitalization.	65.3 %

A Comparison of Ten Books Written in September with the Ten Written by the Same Men in June. Books Chosen Entirely at Random, from Different Sections, and Comparison made by Professor Congdon.

September, 1907.	June, 1908.	
62.5 %	86.2 %	Average standing.
24	7	Misspelled words.
59.2 %	83.3 %	Punctuation and capitalization.

Average of All Marks.

September, 1907.	June, 1908.	
69.3 %	83.6 %	Grades on themes as a whole.
	68.6 %	Improvement in spelling.
62.8 %	81 %	Punctuation and capitalization.

One of the most important conclusions of this experiment is that the number of bad spellings made by a class can be reduced two thirds by systematic training for one college year.

The following is a list of misspellings which the writer has collected during the last four years from papers that have come under his notice.

LIST OF MISSPELLINGS.

1. absorbtions.
2. absorbes.
3. accessability.
4. accommadate.
5. accompaning.
6. accurasy.
7. addapted.
8. addmission.
9. adibatic (adiabatic).
10. adition.
11. advanse.
12. ancher.
13. angcor.
14. antharcite.
15. anthricite.
16. anxity.
17. anyletical.
18. appendicities.
19. Applachian.
20. Applichian.
21. aquires.
22. ariving.
23. auxilary.
24. auxialiary.
25. auxillary.
26. baffel.
27. barron (barren).
28. begining.
29. bitumous.
30. boarder (for border).
31. bredth.
32. calcalus.
33. callory (for calorie).
34. centagrade.
35. centeral.
36. coak.
37. coeffecient.
38. cokeing.
38. colapsed.
39. colege (by a professor).

40. colledge.
41. combusted (for burned). The spelling may be right, but the word is a barbarism.
42. consederable.
43. conserning.
44. corosion.
45. corrossion.
46. comparitive.
47. diagriam.
48. cord (for chord).
49. coresponding.
50. corrponding.
51. crusier.
52. cruisier.
53. crusser.
54. dimonds.
55. definate.
56. dependant (adjective).
57. deterimations.
58. differance.
59. diffrence.
60. dissapear.
61. distroy.
62. dore (for door).
63. duribility.
64. easyly.
65. econimical.
66. effecient.
67. effect (for affect).
68. elegible.
69. ellevation.
70. enterance. } Both spellings by
71. enterence. } the same man.
72. erea (area).
73. errecting.
74. examinanions.
75. examanations.
76. explaination.
77. explination.
78. exaust.
79. faliure.
80. fallicy.
81. fireing.
82. furthmore.
83. gallions.
84. guage.
85. hole (for whole).
86. horozontal.
87. indefinately.
88. indispensible.
89. innitial.
90. insoluable.
91. instulation.
92. investations.
93. kenetic.
94. klongomerate.
95. lapp (for lap).
96. latter (for later).
97. lenght.
98. libility.
99. liquidfaction.
100. londitudinal.
101. mantanance.
102. marvlous.
103. mathmatics.
104. mathamatics.
105. meny.
106. milion.
107. Mossouri.
108. occured.
109. accured.
110. accoured.
111. occurres.
112. occuppied.
113. olifant (for olefiant.
114. olifiant.
115. ommission.
116. opperation.
117. oppurtunity (by a graduate).
118. oprate.
119. origional.
120. overhalled (hauled).
121. partical (le).
122. peer (for pier).
123. persuing.
124. petroluim.
125. phenomona.
126. plane (for plain).
127. pointe.

128. practise (noun, for practice). The Standard Dictionary unfortunately authorizes this spelling, although the best usage of the last hundred years is against it. The other dictionaries give "practice."
129. preceivable.
130. preform.
131. preperation (by a high-school principal).
132. presents (for presence).
133. primative.
134. principal (le).
135. proffessor.
136. Quebeck.
137. racio (ratio).
138. realy.
139. recieved.
140. reck (for wreck).
141. recomend.
142. refering.
143. regrarding.
144. repersenting.
145. reveled (for revealed).
146. reveiled (for revealed).
147. rhoestadt (rheostat).
148. rivitters.
149. riverters.
150. rivetiers.
151. seperate.
152. senter (center).
153. sience.
154. slott.
155. significent.
156. similiar.
157. simular.
158. similtaneous.
159. sophamore.
160. sothern.
161. specificly.
162. stoping (for stopping).
163. stubstance.
164. substracting.
165. sufficently.
166. suggar.
167. superintendant.
168. sutiable.
169. terific.
170. tendancy.
171. tendansy.
172. tendensies.
173. Tenesee.
174. Tenessee.
175. tention.
176. temprature.
178. thanksgiven.
179. theoritical.
180. thoughout.
181. throttleing.
182. togeather.
183. tortion.
184. transmition.
185. tripple.
186. trippel.
187. trible.
188. trignometry.
189. untill.
190. volitile.
191. volotile.
192. volumn.
193. varable.
194. verible.
195. veriable.
196. varanda.
197. varities.
198. varrious.
199. verticle.
200. Verginia.
201. wastful.
202. whare.
203. what ever.
204. yeild.

The total number of words that are misspelled by any individual in his own correspondence is very small. The vocabulary actually used by most men contains but a few thousand words and even bad spellers do not make mistakes in spelling more than 100 of them.

The words in the list are not those that are usually found in the lists of hard words in the spelling-book. These hard spelling-book words are rarely misspelled because they are rarely used.

The most common cause of bad spelling is indifference and carelessness. Many of the worst errors in the list were made in compositions that were written by ''boiling down'' something that was in an open book before the student's eyes. The spellings Apllachian, anthricite, Tenesee, Mossouri, bitumous, coak, cokeing, were made in essays on American coals, the matter all to be compiled from a book that the students were using. Other errors are due to a lack of knowledge or lack of application of some of the best known rules of orthography, such as those relating to doubling the final consonant, dropping the final ''e,'' etc. The students should be drilled on these words. Another class of errors and the most difficult to overcome are those due to the obscure sound of ''e'' or the short ''u'' in many words. This sound is represented by ''a'' as in ''separate'' and volatile, by ''o'' as in baron, by ''i'' as in sensible, and by ''u'' as in simultaneous. Difficulties due to the terminations ''able'' and ''ible'' are of this class. Some of these errors may be overcome by the use of a mnemonic system. Thus, one may remember that to separate means to part and that the letters ''par'' are in both words.

JOINT DISCUSSION.

PROFESSOR H. W. HIBBARD: I very heartily approve of what has been said, and I want to add one thing. I think that all that has been said has referred to written English. I want to say something for *spoken English.* I am a member of certain engineering societies of which only one of you gentlemen present is a member. The men in these societies are usually not technically or university educated men, yet in the discussions of engineering questions some of those men who are not educated men might put to shame some of the men in other societies who come from our universities of engineering. For the past thirteen years I have been giving an elective course which may be called engineering discussion. This past year, in Cornell, there were some 29 seniors who elected that course—it is an engineering discussion club, open to seniors, graduates and to juniors in the second term. The discussion is on previously assigned engineering topics—systematic reading; special papers and reports; forming of an individual card index; training in addressing audiences,—one hour per week during the year.

I have brought some copies of a pamphlet entitled "Engineering Periodicals and the Card Index," and I think I have enough so that each of you may have one, and will pass them around after I get through speaking. I have endeavored to show to the students reading them the value of such an engineering discussion club, and the value of reading the engineering periodicals. I will quote:

"A subscription to a paper should not be made in a hurry. And yet the reading from the start should be carried on with that end always in view. After the different papers become known, then the heart of the very human editor should be gladdened by a little note of appreciation—with some of that necessity for which he works, though not chiefly. A *good* engineering paper should be one of the life partners, ready at hand when moments of leisure permit its instruction and enjoyment, better understood and liked as the years roll on; and there should be acquaintance or perhaps friendship formed with its editor, contributions made, suggestions given and taken, and some share in its mighty influence in the engineering world.

"A union of readers will economize time and enable each to cover more ground and gain greater good. A reading club for discussion, 'seminary,' in university parlance, in which each member reads one or two papers and reports upon his leading articles to the rest, is an excellent institution in Sibley and afterwards. It has frequently been run with success by the younger men gathered from a railway drafting room, test department, and even includes some of the more ambitious younger men of the shop. Sometimes a deferred and announced discussion, or an occasional more formally prepared paper, is a useful addition and promotes deeper thinking. Such a club adds to the advantage of reader coming into contact with paper, the decided advantage of more open friction between man and man, a defending of one's position, an acquirement of ability to think while talking, a cultivation of logical placing of thought and word, so necessary for the engineer who must present his ideas to others with force."

I have always said to the students taking this course, that it is a decided advantage to the young man who is just entering upon his engineering work to be a member of at least one of the various engineering clubs, the one nearest to his place of business, and to take part in the discussions, and that it is of advantage to him to present information in the form of a paper to some engineering periodical, and thus he may become noticed by the elders among the engineers, upon whose recognition he must depend for promotion.

"This rubbing against one's fellows in like pursuits is, by the way, not among the least of the advantages of a college education in general.

"Years afterward, when official responsibilities come, this earlier training will bear good fruit. A superintendent's office will take regularly several papers or several copies of one most useful paper. He marks in these papers articles appropriate for the instruction or spurring of particular subordinates and sends them out. Later he will call for meetings of these heads of divisions or departments in his office; and the resulting interchange of opinions on the papers, tempered with experience, will prove of decided advantage to the business, promoting unanimity of feeling between the departments and the introduction of the best methods suited for each, or perhaps all. The speaker recalls with much pleasure such meetings on the Lehigh Valley Railroad, and has been told only recently by President Vreeland of the Metropolitan Street Railway of New York City, of the success attending his marking of such articles and sending them out, not merely to subordinates, but to some thousands of motormen and gripmen."

And, on another page:

"Where a number of technical papers are to be read each week or month, it becomes essential to learn how to get the cream without drinking all the pans of milk. It is out of the question to read them all thoroughly. Before attempting any reading, an engineer should look them all over and note important articles to be read later if possible. In this way there is obtained a general idea of the contents of the papers and also of the relative importance to him of the articles noted. These are then carefully read in the order of merit, so far as time will permit. In this way one will see and read many things of the first importance, whereas without such a preliminary glance through the papers they might have been missed. Without going through papers, it cannot be known what they contain; while to begin and read as you go, results in using up all the time over matter which may be of little relative importance. One must, however, avoid the danger of being satisfied with the preliminary skimming; the thorough reading must follow."

I want to say that when the students take part in this engineering discussion club I am ex-officio chairman and sit at the desk. Each student, when presenting his contribution, leaves his place in the room and comes to the front and faces the audience. I do not allow them to read; I urge them to have their subjects so well prepared that they can look into the eyes of the audience and, with a speaking eye, carry greater force than if their eyes were upon their notes. I believe that this way of presenting to the students the advantage of this study of English is a reenforcement of what the first speaker said; it shows them the value of it. You know our students are so set upon the goal of the practical that they do not appreciate or care for the English, or they seem to think it of no value in aiding them to attain the goal of success in engineering. Now if we can present the study of English, whether written English or spoken English, in a way that will appeal to the practical young fellows, then two thirds of the battle has been won.

Dean Benjamin: I want to say just a word about this subject, because I am very much interested and believe that the study of English in the ways indicated is one of the most important things that there is in the technical school. I believe that in order to be successful you must reconcile the men who teach freshman and sophomore English with the men who teach engineering in the last two years of the courses, and that all must have a common aim and a common understanding. We leave the freshman and sophomore pretty much to himself as regards his English education and he learns to read, we will say, Tennyson and Browning, and perhaps some of the early English poets, but he does not learn to write. We must recognize the fact that there are two reasons for having English in technical schools: to give a facility in writing good English, and to cultivate the habit of reading good English. We must not lose sight of the latter when we are teaching the former. But there is also this practical consideration which demands that a man be able to investigate a subject and "get the cream" of it; to write it out in intelligible language, and to speak about it, if necessary, before a convention like this. Until he can do that he is neither a good student nor a good engineer.

Now we must get two classes of teachers together—that is, those who teach literary English, what we call the ornamental, and those who teach practical subjects. I believe that one is just as important in our technical schools as the other, and I believe that each ought to be given its due weight in the curriculum; but we must get them together and not train students to be able simply to read Browning and understand it. We must also train them to write a good business letter that is clear to the man addressed; to write it on time, instead of a month too late; to describe anything that they see; to use language that the other man can understand; to write ordinary contracts and specifications that will stand the usual tests and to express themselves before an audience without disgracing the institution to which they belong.

Professor Breitenbach: The common indifference or prejudice of engineering freshmen in regard to the study of English may be attributed, I think, to three causes: (1) ineffective preparatory training in the subject, (2) failure to comprehend the true nature and scope of the study of English, (3) failure to understand the function of the engineer.

The first of these I shall dismiss with only a word, for this is not the time nor place for discussing it. I will only say that I believe conditions are improving. The teaching of English in secondary schools is becoming more efficient.

For his failure to comprehend the true nature and scope of English study, the engineering student is scarcely to be blamed, since the misconception is widespread. It is too commonly supposed that the ideal of language is correct grammar. Many a man thinks that the ability to write a letter properly punctuated and containing no grammatical errors constitutes proficiency in English composition. It would be no more absurd to claim that the boy who can solve ordinary problems in arithmetic thereby evinces proficiency in mathematics.

Again the ideal of language is often thought to be prettiness or floweriness of language; attention is devoted to figures of speech and other so-called ornaments of style; students are encouraged to produce "highfalutin" nonsense about weird subjects on which they never had any first-hand knowledge. Corresponding to this view of composition is that theory of literature that considers it designed merely for amusement and pastime.

When students come to college with such erroneous notions of the subject, it is no wonder that they are indifferent or disinclined toward its further study. Then the teacher's task to make them see that language is intimately related to reality, and that, practically speaking, thought and language are inseparable, is a difficult one. The teacher will, of course, require correct grammar, punctuation and spelling, but only as a means, not as an end; these have value only as they are serviceable conventions. But what is of real importance to the teacher of composition is the thought in the student's mind. The teacher's business is so to train the student's powers of observation, and so to develop and organize his powers of thought that clear and accurate expression will be the natural accompaniment. In a corresponding way, he views literature as a representation of life and its study as the endeavor to interpret the experience of others in terms of one's own experience.

It is difficult, as I said, to make the engineering student appreciate the real nature and scope of English; yet it is possible. It is most effectively accomplished, not by abstract discussions, but by vital teaching, by such teaching as makes the student see his relations with the world he lives in and feel the need of more intimate communication with his fellows.

The third cause I mentioned is the student's mistaken conception of what an engineer really is. The student is apt to think that he himself by virtue simply of enrollment in an engineering school, has thereby become an engineer; or if not that, then surely upon graduation he will be. It is difficult to convince the student that even the graduate has yet a long and laborious period of service before he can justly lay claim to the title of engineer. But this knowledge, once acquired, is both chastening and salutary. When he can be made to comprehend the true function of the engineer, he will note that as a professional man he has a vital and ever-increasing need for communication with his fellowmen. Of these two means of expression, the drawing and the spoken or written word, the latter becomes increasingly important as he advances in his profession. To say nothing of the cultural value of English, its practical value for the engineer is scarcely to be overestimated. The engineering profession is rapidly becoming aware of this. I have in my possession some fifty letters from prominent engineers discussing the subject of English, and every one of the writers testifies to its great importance. For the engineer is coming to realize that as an applied scientist whose objective point is "the use and convenience of man," he must make his knowledge humanly serviceable, not only by embodying it in structures and machines, but by extending the range of it as knowledge. To make the engineering student comprehend the true function of the engineer not only awakens him to a new appreciation of the meaning and value of English, but, I think, should help to start him on the road to becoming a worthy member of a great profession.

DEAN GOSS: I agree heartily with the most of what has just been said, but would like to emphasize the fact that, in my opinion, progress in the teaching of English to engineering students must depend largely upon the attitude of the engineers themselves. In proportion as we, the engineers, become interested in the progress of our students in the matter of English, just to that degree we shall secure the desired results. I therefore hope that we shall avoid an attitude which places the teachers of engineering on one side of a line and the teachers of English on the other side. We should feel most thoroughly and sincerely our responsibilities in this matter. With such a feeling we shall, I am sure, make very rapid progress along the line which we have been discussing.

PROFESSOR D. C. JACKSON: Dean Goss's remarks are of a kind that I want to heartily endorse. He has summed the matter up just as I would like to see it summed up. My experience has been in this way—that the English teachers are anxious to teach English in such a way that it is interesting to the students, and so that they may become capable of expressing their thoughts in strong, terse, able English, not flowery, nor decorated. Engineering teachers have often urged that this is a necessity, and they have very often given assistance to the English teachers. My experience extends to a number of places, and I have found that the English teachers are ready to heartily cooperate whenever we cooperate from our side, but there is a good deal of difficulty, in many instances, to get engineering teachers to cooperate properly so that the English teachers may know how best to carry out their duties. I have also found that when the engineering teachers have gone into such cooperation heartily, the students themselves find that English is a very useful and interesting study.

Mr. Hamerschlag: I would like to add a small contribution, as a layman, to the subject of English instruction. In my judgment, English training does not belong in the school of engineering. It belongs to the secondary schools. If it is ineffectully handled there, the individual who enters the engineering school deficient in this subject should receive some special kind of treatment. I think the student who is deficient ought to be compelled to remove this condition during his first year and it should be made impossible for him to go on with the second year's work in the college until he had given evidence of an ability to meet the usual English requirements. This is another way of saying that concentrated study of English during the first college year for the conditioned student may solve the problem of the student's advancement.

There are three definite methods of improving the student's command of English: (1) by the description of an object within the range of vision in good, clear English; (2) to visualize in words, an object that he has seen but that is no longer within the range of his vision; (3) to express a thought not connected with an object in the range of vision, nor descriptive of any object even seen. The amplification of these three tests ought to give the student the ability to write clearly and concisely and, in my judgment, it is more effective than a whole year of drill, one or two hours a week, on the rules of grammar or on general literary discussion.

DEAN EDDY: It happens that there is here reporting this meeting a young gentleman who has just graduated from the University of Minnesota and who has made, with his engineering studies, a particular study of English and is specially interested in that, and it seemed to me that it might be interesting to you to hear his views, as he is a specialist in the subject and has already commenced his career as a reporter. He is Mr. H. Cole Estep.

MR. H. COLE ESTEP: There was one thing in the work in English that has not been mentioned here that is of interest. That is, the work which is done in the student engineering societies and its effect on the students' work in English. In Minnesota our engineering society holds meetings every two weeks. In the last two years we have made a specialty of presenting topics of interest which the students themselves have looked up, and of discussing them as much as we could, as is done in older societies, and we have found a great deal of benefit from it. The boys who work in the shops in the summer come back in the fall and tell their friends about their summer's work and discuss it at the society meetings. The chief difficulty is that it is hard to get the boys to discuss matters; however, it has done good.

The society also publishes a year-book, and in the last two years it has been the policy of the editorial boards to get as many students' contributions as they could. Last year we had two such contributions, and this year three. I have had the pleasure of editing this publication, and I have found considerable difficulty in getting copy for three contributions until I went after it personally and saw that it was written; however, after they were written they were creditable pieces of work. This matter of student contributions is a thing which I think could be developed to a considerable extent.

Dean Raymond: I wish to say that it is my belief that the existing condition of things is not the final condition, but that there is a very small bright spot on a very distant horizon that indicates the exceedingly slow approach of that good time when all of the high grade engineering schools of the country will open their doors to only the holders of the degree of A.B.

Professor Telleen: The English courses in most of our technical schools are not purely literary. The tendency toward practical work is evident. At Tufts College, for example, a course is given in technical literature, the details of which I am not in position to give. In the University of Michigan two courses are given on scientific literature, one in journalism, and another in specifications and contracts.

Furthermore, you will find that in these courses the emphasis is not placed solely on the petty details of composition work. I agree with the last speaker that such work should be left to our preparatory schools. Nevertheless, present conditions necessitate our giving, where this is possible, special courses for those freshmen who are found deficient in their knowledge of grammar and their ability to apply the simple rules of composition. The task of the teacher of English in our technical schools is to teach the students broadly to apply the principles of composition in their particular field of work.

My paper, I believe, emphasized the value of public speaking. Personally, I consider such work so important that I require every freshman to give a five minute talk on some subject in which he is interested, and the sophomore, a fifteen minute talk. In the giving of these talks the student is urged to be natural in his delivery and clear in the exposition of his subject. Accordingly, diagrams as well as other forms of illustration are required wherever these will insure greater clearness.

Dean Kent: There is one thing in my paper that I wish particularly to call attention to and would like to have the committee on general education consider.

The question is: How can we measure the efficiency of our engineering schools? Can we tell, in any way, whether one school or system or class is any better than another? I have shown that in spelling, two thirds of the errors made by the ordinary freshman can be corrected by one year's instruction; can that same result not be accomplished in the high schools? Why is it necessary to take that year in the freshman's class to get that result?

A PROPOSED COURSE IN GENERAL ENGINEERING.

BY HARWOOD FROST,

Editor of *The Engineering Digest.*

During the past few years there has been considerable discussion regarding the character and duration of the college course which would be most suitable, or most profitable for the training of an engineer. The rapid developments in modern engineering science have compelled the introduction of so many specialties into the curriculum that a constant readjustment is necessary, in order to cover the subjects in the regulation period of four years. That many of the leading schools have felt the pressure caused by these specialized subjects, and the need for readjustment, has been shown by their efforts to meet the situation through an increase in their requirements for admission ; the introduction of summer courses and, as in the University of Minnesota, the establishment of a five-year course. The five-year course seems a most logical solution of the problem, especially if it is intended to include, as it undoubtedly should, and as it does at the University of Minnesota, some of the higher branches of the cultural studies, such as languages, literature, history and philosophy. President Schurman has long advocated a five-year course, so has Dr. J. A. L. Waddell, to cite a prominent professional engineer who has also a wide reputation as an educator. On the other hand, five years is a long time and the average young man is impatient to reach a degree of efficiency where he has a definite earning power, and to get into the harness of business. While there is nearly always a demand for engineering services in excess of the supply, there certainly is always a demand for trained men and the engineering graduate often prefers to go out into the world, technically efficient, but uncultured, perhaps, in the subjects that would certainly have made him more broad-minded and a better citizen. Some time ago a five-years' mining course was tried at Lehigh University ; it was wisely planned, and was under competent direction, and there is no doubt that the students would have found the five years well spent ; but it was simply impossible to keep the students longer than the customary four years.

In considering this subject, I do so from the point of view of one interested in the general subject of technical education but to a very considerable extent ignorant of the many difficulties to be overcome in the planning of a curriculum. I have met with many instances where an engineer proficient in one line has been called on to practice in a field that is far removed from his specialty, and of which he is practically ignorant ; and I have seen many cases where the responsibilities of one man cover many and various lines of work. Such cases show the interdependence of the many branches of engineering ; they are now very common, and they indicate that there is a growing necessity for the " general engineer." It is with the details of a proposed curriculum and the term of study for a course of " general engineering " that this paper has to deal.

The subject was taken up in the December, 1907, issue of the *Engineering Digest*, where the editors presented some comments and a table of studies based on an article in "Machinery" and an address by Walter C. Kerr, President of Westinghouse, Church, Kerr & Co., both advocating a "general" in preference to a "specialized" engineering education. I feel that the subject is an important one, and in the present paper I have extended the article referred to and corrected its few inaccuracies, but I wish to emphasize that I make the proposal of a "general engineering" course from the standpoint of a man not sufficiently acquainted with the problems involved, to know whether it is altogether practicable.

The two quotations used as showing the value of a more general education are as follows:

"In these days when so much has been said about specialization and about the necessity for any young man in the technical field to devote himself exclusively to a certain branch, it may be well to accentuate the point that specialization may be carried too far. The man who becomes too one-sided in his work may be useful to a less extent than he would have been had he, while making a particular study of a special field, devoted some time to broadening his intellect in various ways. The truly great men of this, as well as former ages are men who have not confined themselves to a small sphere of usefulness. It is true that it will not do to divide one's interests between too many things at a time. Do one thing at a time, and do it well, but do not think that the time has come when general information in regard to all the things that surround us in life is useless simply because it is not possible to become master of all the arts. Perhaps, on the other hand, there never was a time when the man with a broad view had a greater chance. The specialization in all lines of industry has limited the opportunities for the development of men of varied experiences, but such men are necessary for the executive positions. There is for this reason a premium on the services of the man who has been able to acquire a general, even if limited, knowledge of the industries, the business and other conditions outside of his own branch ; and because such knowledge is becoming more scarce, as the specialization becomes more systematized, there is all the more reason for not being deluded by the general outcry that a man to be truly successful must be a specialist, and nothing but a specialist. To a certain limit the man who is a specialist, and nothing but a specialist, is more successful than his fellow-workers ; but this is in the secondary positions, when he is working under the guidance of men who can supplement his lack of general development. When the moment comes that the place of managing the whole concern is to be filled, the specialist is left where he is, because he is filling his place so exceeding well, and the man who never was thought much of where but one of his many faculties came into play, is promoted to the place where he can give full sway to his general knowledge and his varied interests ; and the specialist who in his one-sidedness thinks that he was the person logically fit for the promotion, thinks himself badly ignored and his ability misunderstood ; he does not realize that with all our specialization the ' all around man ' still holds his own."— *Machinery.*

" Each of you probably has a preconceived notion of following some line of engineering. Be careful about your self-analysis. The field is large and has room for all of the various types of men, some of whom incline to constructive operations, others towards inventive, some to the contemplative. Again, within all these divisions, some tend toward professional and others towards trade work. No one can advise what is best for you ; this you must find out for yourself. I cannot help, however, a certain predilection in favor of a young man being just an engineer—not specializing while too young, but developing along versatile lines, ready to turn his hand equally well to any task within his general scope."—Walter C. Kerr, president of the Westinghouse, Church, Kerr & Co., in an address to the graduating class, Stevens Institute of Technology, June 16, 1904.

For the preparation of this " all around man " who is "just an engineer," some scheme of educational training would seem to be required that is broader in its scope than any in present practice, so far as the writer is aware. In the four years that are ordinarily devoted to the technical education of young men, is it possible to instruct them, or the fittest of them, in the essentials of civil, mechanical, electrical, mining and metallurgical engineering ? At first sight, no ! But let us see.

In the accompanying schedule (I.) are listed all the various studies and laboratory exercises embodied in these five courses in one of the foremost engineering schools of the country (Massachusetts Institute of Technology), with the hours which I propose to assign to each, and against these items are set (in parentheses) the actual number of hours devoted to each item in the several courses of that school. The figures are taken from the December, 1906, Catalogue, but I find that the alterations in the 1907 Catalogue are not sufficient to warrant any alteration in the general plan. The total number of hours required for the full courses in the five branches is 10,393, divided as follows :

	Hours.
Study, lectures and recitations	6,872
Laboratory exercises	1,958
Drawing and field work	1,563
Total	10,393

These courses, at 48 hours a week, would require from the student more than seven of the 30-week years at this institution for completion in their entirety. On the other hand, there are a number of high-grade technical schools (Lehigh, Rose, Case, Purdue, Stevens, Cornell and others) in which the duration of the school year is 35 or 36 weeks, and one or two in which it is 37 weeks, while the time devoted to study, recitations and laboratory work at these institutions varies from 54 to 57 hours instead of the 48 just mentioned. In addition, some of these schools supplement their regular instruction by summer terms of from four to eight weeks in length, devoted chiefly to field work or shop practice.

SCHEDULE (I.)

The main figures in Schedule (I.) show the number of hours proposed for a " general engineering " course. These are based on a study of the time allotted to similar subjects in other schools, and in all but three or four instances the reduced number of hours given is greater than the time devoted to the subjects in at least one school of high standing; that is, with these three or four exceptions, no allotment of time is less than is considered sufficient for the subject by some high-grade school. In the few exceptional cases, the reduction is inconsiderable, and leaves in each case at least 85 per cent. of the maximum time required for the subjects in a specialized course. It will be found, by comparison with the actual time devoted to the subjects in any given school, in the same way that the comparison with the Massachusetts Institute of Technology has been made, that a fair average time has been allotted to each.

SCHEDULE I.

Course in General Engineering.

General.

	Study, Lectures and Recitations.	Laboratory Work.	Drawing and Field Work.
Mathematics	780 (780)		
Physics	340 (340)	85 (85)	
Chemistry	420 (480)	398 (443)	
French	120 (270)		
German	240 (270)		
Applied mechanics	405 (405)	75 (90)	
Hydraulics	135 (135)	50 (50)	
Descriptive geometry and drawing			270 (330)
Engineering laboratory	45 (67)	135 (135)	
Geology	335 (385)	180 (260)	
Materials	45 (45)		
Political economy	90 (90)		
Corporations, contracts and business law	75 (75)		
Costs, management, etc.	30 (30)		

	Study, Lectures and Recitations.		Laboratory Work.		Drawing and Field Work.	
Civil Engineering.						
Biology	15	(15)				
Bridge design					150	(180)
Astronomy and Geodesy	90	(105)				
Stereotomy					30	(60)
Structures and foundations	450	(495)				
Surveying and topography	60	(60)			210	(225)
Highway engineering	30	(30)				
Railroad design					90	(105)
Railway drawing and field work					105	(135)
Railroad engineering	270	(330)				
Sewerage and water supply	180	(210)			30	(30)
Electrical Engineering	600	(705)	205	(255)	40	(40)
Mechanical Engineering.						
Dynamics of machines	75	(75)				
Hydraulic machinery	75	(90)				
Shopwork			420	(450)		
Steam engineering and thermodynamics	270	(270)				
Heating and ventilation	15	(15)				
Locomotive engineering	90	(225)				
Machine design and drawing					387	(458)
Mining and Metallurgy	395	(545)	150	(190)		
also						
English Literature and Rhetoric	150	(210)				
History—United States and Europe	45	(120)				
Total, 8,880 hours	5,870	(6,872)	1,698	(1,958)	1,312	(1,563)
Total, (10,393) hours.						

The total number of hours as given in this proposed schedule is 8,880, or over 1,500 hours less than that required by the full courses of the Massachusetts Institute of Technology. In making these calculations the following factors were taken into consideration :

BASIC STUDIES GIVEN FULL TIME.

Mathematics; physics; applied mechanics; hydraulics; materials; steam engineering and thermodynamics.

Laboratory work = (1698 ÷ 1958) = 87 per cent. of full time given.

Drawing and field work = (1312 ÷ 1563) = 84 per cent. of full time given.

As much time on drawing as in any single course.

In civil engineering drawing and field work 87 per cent. of full time.

In mechanical engineering and electrical engineering drawing and design 86 per cent. of full time.

Principal Reductions in Time Devoted to Studies.

	Hours.	
Chemistry	60	(Descriptive portions.)
Geology	50	(Descriptive portions.)
Structures	45	(Work on higher structures abbreviated.)
Railroad engineering	60	(Descriptive portions.)
Sewerage and water supply	30	(Descriptive portions.)
Locomotive engineering	135	(This is given as an optional study of 225 hours. Of decreasing importance on account of increasing importance of electric traction; thought that a sufficient outline can be given in 90 hours.)
Mining and metallurgy	150	(Time saved by having lectures instead of recitations on ore dressing, mining machinery and metallurgical processes, which need not be studied, as the matter is descriptive and can be referred to later in books when needed.)
History	75	(United States history cut out—assumed to be properly an entrance requirement. European history condensed 15 hours.)

This schedule, or any similar one, should not be made hard and fast. Individual judgment would, no doubt, change some of the allotments of time, but, withal, it is thought that the basic studies are given sufficient attention, and that the shortened courses are sufficiently long to give the student a good grounding in each of them. With the broadening of engineering work come extensions in various lines of study, and in order to cover the ground more thoroughly in the four years, the entrance requirements to the higher grade schools are being raised, as, for instance, the Carnegie Foundation requiring two years' French and German as an entrance qualification, and the recommendation by the Association of American Universities of two years of academic work as a requirement for admission to any engineering school. This permits of a corresponding reduction in the time devoted to languages, history and English literature without material loss, and the hours thus gained can be applied to studies that may seem to be unduly condensed.

As an alternative to the foregoing general course, which covers practically all the divisions of engineering and may be considered by some too diverse, and in certain details too abbreviated, Schedule II. is presented, giving a combination civil, mechanical and electrical engineering course. This schedule is also compiled from the courses as given in the Massachusetts Institute of Technology, and comprises the *full actual time allotted to the three courses.* It totals 8,863 hours, the reduction of 1,530 hours being caused by the overlapping of studies in the courses when taken separately.

SCHEDULE II.

For the purpose of these observations a four-year course of thirty-nine 57-hour weeks, or a five-year course of thirty-six 50-hour weeks has been assumed, the former, amounting to a total of 8,892 hours, and the latter to 9,000 hours. As the total number of hours given in either of the proposed schedules amounts to nearly these totals, it would seem that, to accomplish all of these studies in four years it would be necessary to omit thesis work, but if carried over five years sufficient time for a thesis would be allowed.

SCHEDULE II.

Full Schedule of Studies at the Massachusetts Institute of Technology in the Combined Civil Engineering, Mechanical Engineering and Electrical Engineering Courses.

	Study, Lectures and Recitations.	Laboratory Work.	Drawing and Field Work.
Mathematics	780		
Applied mechanics	405	90	
Descriptive geometry, free-hand and mechanical drawing			330
Shopwork		450	
English literature and rhetoric	210		
Economics	165		
History	120		
French and German	540		
Civil engineering	1,515	35	735
Metallurgy of iron	30		
Mechanical engineering	952	135	458
Chemistry	270	128	
Physics	550*	135†	
Electrical engineering	495	205	40
Geology	60	30	
	6,092	1,208	1,563

Total, 8,863 hours.

* 210 hours of physics study devoted to electricity.

† 50 hours of laboratory work on electrical instruments.

While the general subject of the thesis is not altogether within the province of the present discussion, it may be mentioned that the practical value of this work in connection with this proposed course, is open to considerable discussion. Primarily, the object of a thesis is to give valuable data to the engineering world, and to test and increase the ability of the student to carry on independent investigations with that end in view. Actually, however, in the great majority of schools the thesis does not accomplish these desired results, simply because engineering students, when acting alone, are not capable of doing this thorough research work. When assisted by an experienced man these undergraduate researches often secure valuable results, but most teachers in technical schools are not sufficiently free from the daily routine of the class room to enable them to devote much, if any, time to thought and supervision of this work of investigation. In other words, most technical schools in this country are so engrossed in teaching existing knowledge that they are unable to add much to this knowledge. As a result of this condition of affairs the thesis is usually the mere execution of some problem, from which the student may or may not learn something, and by which he shows the faculty that he is or is not capable of executing this work alone. But a glance over almost any list of subjects chosen by students would show that in many cases the time consumed in the writing might be more profitably spent otherwise, as in very few instances is there any display of exceptional abilities or evidence of real original investigation or study.

Another point that has been brought to my attention in connection with the duration of the course, is, that in the attempt to obtain the maximum educational value of a large number of subjects within an available number of hours, there is a possibility of improvement in many educational institutions through a process of condensation and concentration of some of the subject matter taught. To illustrate this more specifically : let almost any man, say Mr. Smith, write an article on a subject with which any other man, say Mr. Jones, may be familiar. Mr. Jones can take that article and cut it down from 20 to 50 per cent. and leave the substance all there. Then, Mr. Jones could write an article on some subject with which Mr. Smith is familiar, and he could do the same thing with Mr. Jones' writing. The original writer of an article is liable to err in profusion of words and descriptive detail, and the more profound the subject and the longer the writing, the more opportunity usually exists for such revision.

Now, in like manner, a professor or instructor who conducts certain courses of instruction may get his subjects diluted with various thoughts and words that are not essential to the main object. Especially is this the case where a subject has been long continued, and the man in charge has injected into it pretty much everything that has occurred to him. Thus, courses of lectures, though most excellent in quality, frequently run into quantity in excess of the time necessary for imparting the essentials of the subject.

It is not unnatural for each man to think that nearly all he has evolved is essential, but it is nevertheless true that careful revision by some able man in authority, or by a practical man not connected with the school, of a large amount of the instruction given in the various courses, would, in many cases, be productive of an economy of time similar to the economies that are worked in engineering, manufacturing, and commercial operations.

While such economy of time has a distinct bearing upon the principal motive of this paper, it is with considerable hesitation that the point is raised here, even in a general way, as it can become effective only when raised specifically by some one in authority who can carry it out, and that, too, with sufficient diplomacy to avoid the friction which would naturally arise. To do such work in any educational institution, the entire teaching force must be in harmony and in the spirit of the motive—only then will they cooperate, and not oppose.

From the schedules herewith presented, and especially from the second, taken from the catalogue of one of the largest (3,500 graduates) technical schools in the country, with nearly half a century's experience in the making of engineers (Massachusetts Institute of Technology, founded 1859), it is seen that :

1. It is possible for a student working four years, each of 39 weeks, 57 hours each week (which is no more than is expected in many institutions, and much less rigorous than the work at Annapolis and West Point) to be well educated in civil, mechanical and electrical engineering, and thus have all the advantages that come from a broad technical training.

By the time he is ready to receive his degree the student will have become acquainted with the rudiments of three great subdivisions of engineering, and have had a thorough training in the basic studies of mathematics, physics, chemistry, mechanics and drawing; he will then be prepared to develop along the line most fitted to his temperament and inclinations and to select for his life work the branch that appeals to him most, after having become intimately acquainted with the details of each — decidedly more advantageous than being compelled, as under the present system, to choose for himself at the age of 16 or 18, without such knowledge.

3. If, after graduation, it is difficult to obtain employment in one line, the "general" engineering graduate has two other fields to turn to, in both of which he is equally well trained.

As a single instance of the broad field of work looming up for the "general" engineer and a field in which an engineer with a general training is needed, may be mentioned that of electric railway engineering. The relationship of such an engineer to his work might be outlined roughly as follows:

Structures Road bed Survey and location, etc.	Civil engineering	General engineer.
Power houses Rolling stock, etc.	Mechanical engineering	
Generators Transmission Electric locomotives, etc.	Electrical engineering	

There are difficulties to be encountered in the establishment of such a course, such as the necessity for more instructors and much greater equipments, but these are matters involving financial considerations, and do not affect the feasibility of the proposition, if it otherwise commends itself. There is a growing demand for the "general engineer," and when this demand reaches proportions where it cannot be overlooked, enlightened philanthropists will, no doubt, be found, who will provide the ways and means for meeting it. Meanwhile, the subject is one that seems to merit consideration.

MECHANICAL ENGINEERING CURRICULUMS.

BY WM. T. MAGRUDER,

Professor of Mechanical Engineering, Ohio State University.

It is the practice of manufacturing and other business organizations to take an account of stock at least once a year, and to find out their condition by comparing their present with past inventories, and their business conditions with those of other companies, competitors and friends, as nearly as the latter can be learned. Similarly, it is well for educational institutions occasionally to make comparisons of themselves with their rivals, and to inquire if their equipments, courses of study, and the like, are up-to-date. With the desire in mind of suggesting modifications in the curriculum of mechanical engineering at the Ohio State University, of adding new courses, offering electives, and of bringing the curriculum more up-to-date, the accompanying study has been made of the existing curriculums of twenty-six of the larger engineering colleges of the country.

A table was prepared, four feet by six feet in size, which gives the details of the mechanical engineering curriculum of each institution considered. Economic limitations forbade including all institutions. Earnest efforts were made to obtain the data for the lately revised curriculum at the University of Wisconsin, but without success. The information was obtained from the latest catalogues, 1906–07 or 1907–08, and put into the tabular form by course-number, year of course, term, number of credit hours, and of actual or clock hours of lecture, recitation and practice per week. It was then submitted to the dean of the college of engineering, or to the professor of mechanical engineering, of the institution, corrected by him, and retabulated in corrected form. Notwithstanding the care that has been taken, it is quite probable that there are still a number of errors, or inaccuracies, which would have been corrected if they had been known.

On account of the prohibitive cost for the reproduction of this large table, a summary, Table I., has been made of the mechanical engineering curriculums by subject groups.*

In comparing the various curriculums, it must be borne in mind that certain subjects are classified differently at the various institutions. For example, practice work with us in materials of engineering is included in engineering laboratory work, and elsewhere under mechanics.

It must be remembered that the requirements for admission are different, being usually higher at the eastern institutions than in the states of the Central West and Pacific slope, hence a curriculum having fewer hours at one institution may carry a student as far as one of more hours of another institution.

All the curriculums here given are four years long, except that of the Sheffield Science School at Yale University, which is three years long. Some of the colleges have one or more supplementary practice terms in summer (Columbia, Lehigh, Ohio State, Cincinnati, Case, Pennsylvania State, Washington, Worcester) or in winter (Stevens).

---

* On receipt of fifty cents to cover the cost, the author will send a blue print of this large table.

The following details may be of special interest. English is not a required subject at Columbia, Cornell, Leland Stanford or California. The number of hours scheduled varies from 64 hours at Michigan and Nebraska to 224 hours at the University of Illinois.

French and German, but not Spanish, are optional at Cincinnati, Lehigh, Massachusetts, Pennsylvania State, Pennsylvania, Washington, Worcester, and Yale. Spanish is optional with French, German, and additional English at Illinois, 128 hours of recitation. Spanish is optional with French or German at Armour, Iowa State, Ohio State, Illinois, Kansas, and Michigan. Spanish is optional with French at Case, 170 recitations. Spanish is elective at Stevens, 112 recitations. German is required at Case (170 hours), New York (96 hours), Purdue (180 hours), Stevens (247 hours). No French is required or optional at Purdue or Stevens. French and German are both required at New York University (96 hours each). At Columbia, Cornell, Leland Stanford, Syracuse, California, Illinois, Minnesota, Missouri and Nebraska the study of foreign languages is not required. At Illinois, they are optional with English. The number of hours scheduled varies from 90 at Massachusetts and 102 at Armour and Iowa State to 340 at Case.

Instruction in mathematics ranges from 182 at Cornell to 396 at Purdue.

Drawing ranges from 128 at Lehigh to 612 at Case.

Mechanism and machine design range from 208 at California and Pennsylvania and 232 at Case to 898 at Columbia and 936 at Syracuse.

The time allotted to chemistry and metallurgy ranges from 140 at Yale to 527 at Armour and 537 at Columbia.

Physics ranges from 128 at Pennsylvania State to 391 at Iowa State and 544 at Worcester.

Electrical engineering ranges from a total of 75 at Leland Stanford, 90 at Massachusetts, and 96 at Illinois and Purdue to 362 at Missouri and 400 at Pennsylvania.

History is required at Armour, Iowa State, Massachusetts, Pennsylvania State, and Purdue, and ranges from 34 at Iowa State to 96 at Pennsylvania State.

Economics and political science are required at Armour, Case, Columbia, Cornell, Iowa State, Lehigh, Massachusetts, Minnesota, New York, Pennsylvania State, Purdue, Illinois, Missouri, Washington, and Worcester, and range from 32 at Lehigh and Missouri, and 34 at Case to 224 at Worcester.

Of other cultural studies, Armour requires 68 hours in logic and psychology, New York 48 hours in philosophy, and Stevens requires 56 hours in logic. Instruction in mechanics ranges from 144 hours at Syracuse to 415 hours at Leland Stanford and 539 hours at Columbia.

Thirty-six hours in photography is required at Ohio State.

Instruction in materials of engineering ranges from 16 at Worcester to 85 at Case.

Structural engineering ranges from 15 hours of lectures at Massachusetts to 192 hours of practice at California.

The summation of instruction given in mechanics, materials of engineering, and structural engineering ranges from 144 at Syracuse to 539 at Columbia.

Some work is required in surveying at 15 of the 26 institutions with a maximum of 288 hours at New York and 352 at California. Shopwork ranges from 150 hours at New York, 195 hours at Washington to 802 hours at Minnesota, 828 hours at Purdue to 1,260 at Worcester.

Mechanical engineering laboratory work ranges from 32 hours at New York University to 341 hours at Armour, 352 at Lehigh and Syracuse, and 384 hours at Nebraska.

Mechanical engineering subjects other than shop and laboratory range from a total of 50 hours at Stevens and 114 hours at Cornell to 766 hours at Columbia.

Engineering practice ranges from 25 hours at Pennsylvania State to 298 at Columbia, and is scheduled by this title at 8 institutions. Out-of-town inspection trips are required at Case, Lehigh, Ohio State, Purdue, and Stevens.

Some work in estimates, contracts, and engineering law is given at 17 institutions and ranges from 15 at Massachusetts, 16 at Iowa State, Pennsylvania State, Syracuse, Missouri, and Worcester to 64 at New York and 68 at Armour.

Electives are allowed at five institutions as follows: 120 actual hours at Massachusetts, 2 credit hours at Illinois, 3 credit hours at Michigan, 6 credit hours at Cornell, California and Minnesota, 7 credit hours at Nebraska, and 12 credit hours at Missouri.

A thesis is required for the bachelor degree at all institutions except Columbia, Cornell, Leland Stanford, Michigan and Yale. A thesis is elective at Cornell and Michigan. The allowance for thesis ranges from 3 credit hours at Lehigh to 8 credit hours at Cornell and Purdue, and 12 credit hours at Worcester, and from 32 clock hours at New York University to 256 clock hours at Cincinnati. Of the 26 institutions, 15 give the degree of B.S., 8 give the degree of M.E., while Leland Stanford gives B.A., Massachusetts gives S.B. and Yale gives B.Ph.

Lecture work in colleges giving the B.S. degree ranges from 16 at Pennsylvania State, 64 at Yale, 102 at Case, 112 at Illinois to 640 at New York and 703 at Massachusetts. Lecture work in colleges giving the M.E. degree as the first degree ranges from 176 at Lehigh to 1231 hours at Columbia.

Recitation work among those colleges giving the B.S. degree ranges from 791 at Leland Stanford, 849 at California to 1960 at Case. Recitation work at the colleges giving the M.E. degree ranges from 741 at Cornell and 833 at Columbia to 1,482 at Ohio State and 1,488 at Lehigh. The 1712 hours scheduled as recitations at Cincinnati includes lectures.

Practice work among the colleges giving the B.S. degree, or its equivalent, ranges from 456 at Yale, 1,382 at New York, 1,455 at Massachusetts to 2,415 at Iowa State, 2,464 at Nebraska, and 3,052 at Worcester. Practice at those colleges giving the M.E. degree ranges from 1,862 at Lehigh, 2,080 at Ohio

INSERT FOLDOUT HERE

State, 1,973 at Stevens, 2,766 at Minnesota and 2,984 at Columbia.

The total number of hours of instruction in lecture, recitation, and practice among those colleges giving the B.S. degree ranges from 1,706 at Yale to 3,112 at Massachusetts, 3,104 at California, 3,222 at Leland Stanford to 4,618 at Armour and 4,604 at Worcester. The total instruction by hours given in the colleges giving the M.E. degree ranges from 3,526 at Lehigh and 3,563 at Cornell to 4,147 at Minnesota, 4,384 in the regular four-year mechanical engineering curriculum at Cincinnati and 5,048 at Columbia.

The author will be glad to receive suggestions, not only from educators, but from practicing engineers, of what subjects should be included and excluded and to what extent they should be taught in a mechanical engineering curriculum of the highest professional grade. Let the practicing engineer accept this offer and give us practical and workable suggestions, remembering, however, that young men have mental limitations just as much now as was the case when they were boys, and that demands for equipments and new and detailed curriculums have expanded faster than any one human mind can follow.

Discussion.

Professor D. C. Jackson: I have some doubt as to the propriety of drawing hard and fast conclusions from any data of this kind until the chart is compared with the catalogue of the institutions under consideration. The point I want to draw attention to is the fallacy of using such charts, not because the compiler has not done his full duty, but because we do not have enough similarity of subjects in the various colleges to make it possible to put the subjects together so that they will compare. I doubt very much whether we could make a chart which is perfectly safe without going to the individual colleges.

Professor Magruder: I would say that I could only improve upon this by accepting the suggestion of going to each institution and staying there a week to get the facts and figures. These figures have been examined by the head of a department of each institution. I can not say that they are all wrong, but I am thankful to receive as many corrections as possible. Of course we all err, and I am confident that there are errors in the tabulation of this work, and will be glad to have corrections made at any time, either in person or by correspondence.

ADAPTING MEANS TO THE ENDS IN TECHNICAL EDUCATION.

BY ARTHUR L. RICE,
Editor of Practical Engineer, Chicago, Ill.

In a recent article, a man who is in control of a chain of big factories, and who is known for his benefactions to employees and for his interest in education, asks and answers to his own satisfaction the question "Why do technical schools fail?" His solution is that they teach young men to despise real work. Unfortunately for the value of his conclusion as an unbiased opinion, he condemns, in the course of the article, every kind of education, trade, engineering, liberal, and classical, and education in every grade from manual training high school to university *in toto* as destructive and pernicious, and consigns the whole heterogeneous lot of teachers, principals, instructors, professors, deans, presidents and trustees to everlasting torment, as their just desert for so deluding and defrauding earth's young men and maidens. But, manual training up to and through the grammar grade, so he says, is "exceedingly useful."

Notwithstanding our disagreement with Mr. Crane, whose violence in statement destroys the force of his argument, it is evident from the unrest among employers of technically trained men, among the men themselves and among the teachers that all is not right in our system for making mechanics and engineers.

It was natural, in the first attempts to give an engineering course, that an assemblage of studies should be made out of the materials at hand in the classical departments where such courses were introduced in colleges. Courses going to the other extreme were tried, as at Worcester, Mass., and at Urbana, Ill., which were nearly all shop practice. Both plans had good elements; neither gave an engineering course. The apprentice system was then in vogue in the shops of the country so that the need for school-trained workmen did not exist as now. What was sought was a shorter and more certain road to fitness for designing and management of construction than was offered through shop promotion.

Development has proceeded from the classical course toward the shop and from the shop course toward the college until reasonable uniformity has been attained. But, in the meantime, conditions have entirely changed so that these courses are, at the present time, attempting to straddle a situation that refuses to be straddled. If we should go back to the original courses, or to something near them, we should approach a system that would fit the industrial needs of to-day better than do the present courses. Engineering has been intensified along the professional line; so has shop production, railroad building, and power station practice.

Into the old classico-technical course went many boys who were well fitted to become foremen, but who had no imagination. How could they ever become engineers? But they tried hard, and went from these courses into machine shops where they failed from lack of detailed knowledge, and discredited the system.

"Impractical! We must have more 'actual' engineering and not so much theory," was the verdict of the men who paid the wages. But, if the boy was really an embryo engineer, he "got there."

The similar course of events, with the boot on the other foot attended the shop course; but that extreme was the better of the two, for it helped the man who was born to be an engineer in his progress and it left the mechanic not unfitted for the bench.

Now-a-days in order to fit our subdivision of responsibility and labor, we need engineers, men with a liberal education having broad and enlightened minds, captains of industry, fitted to control both men and construction; and artisans who are real craftsmen, not mere machines. But have we technical courses in any way suited to furnish such a variety of men?

Certainly you all have courses that may be made to answer. But are they efficient? The only tools used by the Pilgrims in house construction were spade, ax and saw. They did the work. But a contractor who started a modern building with that outfit to-day would hardly be regarded as having equipment suited to his work. Give him time and he might produce a mansion, a skyscraper, or even a modest bungalow of the $20,000 variety. But wouldn't he do far better to get the right "kit of tools" before he started?

The boy who ought to be and wants to be a good craftsman has just as much right to be properly trained for it without waste of his time or effort as has the one who by nature and by choice is to be responsible for our future inland water ways and great tidal energy power stations. Each also has the right and the need first of all to be helped to the best citizenship of which he is capable, to have his intelligence, sympathy, patriotism and helpfulness developed as much as possible.

The student engineer needs, and should have, a professional training; a liberal education which will discipline the mind, impart an understanding of principles and a knowledge of facts, develop the power of expression, cultivate the emotional sympathy and sharpen the moral faculty. He should be a scholarly man well fitted to become in the highest sense an engineer.

The young craftsman needs manual skill, an active brain and a keen sense of duty; the desire and the trained instinct to find the best and quickest way to do his work; and an artistic sense of proportion which will tell him when such details as are left to his judgment are well done. He needs to know the laws of personal hygiene and the principles of economics and economy, and to have an outlook into the fields of science and good literature which will attract him in those directions rather than to trash for his relaxation.

In between these two comes a third, a course intended for a distinct purpose, the industrial or secondary-technical course, which fits for foremen, superintendents and managers; a course which covers the craftsman's field, some applications of engineering formulas to the design of details, the principles of business organization and of economics. More knowledge of science and mathematics than is needed by the craftsman and some idea of the management of men.

The Society for the Promotion of Industrial Education is advocating a general system for training our youth for vocations. This is sensible if rightly done.

Perhaps the Foremanship training will be solved by some such system as advocated by Mr. F. A. Waldron in the *American Machinist* for April 2, 1908, which provides for progressive evening or other part time training covering foremen, superintendents and managers. Engineering training, to which this society is devoted will then be free to train only engineers; to pick carefully, by a course which shall be sufficiently general in its first year to be useful to all, yet having enough engineering to test the boy's tastes, those who are really fitted for engineering; then to give them the liberal engineering training that they must have if they are to stand in their profession on a par with lawyers, and doctors and other professional men, in leadership, in the routine of business and in all human relations.

THE CORRELATION OF COURSES IN ENGINEERING COLLEGES.

BY GARDNER C. ANTHONY,
Dean of the Department of Engineering, Tufts College.

I desire to state briefly a few of the salient features of that portion of the work at Tufts College which has brought about a greater degree of unity in the work of the engineering school.

My observation leads me to believe that the value of the training in an engineering college is more dependent on an effective correlation throughout a department than on the superior excellence of individual courses. Also, that the student body should be made to realize the interdependence of studies early in their college life and should not regard a subject as completed because the final examination in it has been passed.

To create this appreciation it is necessary for the members of a faculty to work together as a unit in the harmonious development of their courses; and to utilize, as much as possible, the knowledge already acquired by the students. An excellent medium for the inauguration of this cooperative movement is the faculty meeting, the time of which may be more wisely devoted to this subject than to many of the topics that are usually granted consideration. To this end we have found it profitable to spend much of the time of meetings in listening to the presentation of the work of several departments and discussing the details of the courses in their relation to each other for the purpose of creating new and more intimate relations between the departments. I do not believe that this should be done for the purpose of saving repetition due to the overlapping of courses although this may be accomplished at times, but rather to use this common ground for the greater emphasis of fundamental principles and to promote a more logical sequence in courses.

One naturally expects the department of mathematics to cooperate with the courses which are distinctively engineering but we are only just beginning to properly fuse the mathematics and allied courses and to avoid the abrupt transition which formerly existed, as well as to lessen the terrors of a name by introducing the subject matter as a natural sequence of more elementary principles which are known to be harmless.

Professor Ransom, one of our teachers of mathematics, who was new to the work of an engineering school, submitted to his colleagues a list of more than a hundred questions on the uses made of many mathematical topics in technical courses. The answers were made the basis of a series of interviews with engineering instructors concerning the difference between the mathematical and practical attitude toward the instruction in engineering mathematics. The questions related to the character of the problems and formulæ used in the various courses; the method of solution; the accuracy required; the tables, and the mathematical instruments employed. The instructors were asked to indicate the degree of use made of the several topics and to state if they were frequently used; sometimes but seldom used; never used; or if it would be desirable for the student to have greater familiarity with these mathematical tools. This led to the more general consideration of the relation of mathematics to engineering as illustrated by the following:

Ought not the mathematical instructor to recognize that most of an engineer's work is done with approximate numbers, and drill the student on better methods of multiplying, placing the decimal point, and arranging calculations?

Do not reversed multiplication and the slide rule belong to engineering mathematical courses as much as the use of logarithms?

Are the examples used by mathematical writers at all adequate for teaching the use of radian measure and naperian logarithms effectively?

Does the usual course in analytical geometry fail to ensure facility in making the connection between such graphs and equations as arise in practice? Is not the point of view too geometrical and insufficiently graphical?

Does not a student need an earlier acquaintance with the fundamental conceptions of the calculus than is possible when so much attention is given to the working out of derivates and integrals?

Are there not many problems, as for example: projectiles, pendulum, parallelogram law, centrifugal force, elementary beam theory, entropy, errors—that deserve cooperative treatment, their special mathematical features being discussed in the mathematics divisions at the same time that the practical side is being taken up in the appropriate course?

The result of the answers was put to immediate use in the mathematical course and has brought about a complete revision of the methods of teaching and order of subject matter in this department.

The cooperation of the departments of French and graphics has been productive of a mutual stimulus and this has been made easier by reason of their being under the same administration, French courses in the department of engineering being independent of those in the college of letters. Mr. Hayden, our instructor in French, joined a class in descriptive geometry for the purpose of getting into touch with the work of the engineers and to acquaint himself with a course which might serve as a profitable subject for the reading of scientific French. During this period frequent allusions were made to the treatment of the subject by French writers and before the end of the semester Mr. Hayden suggested that the class make use of this material for some of their reading. The class was enthusiastic in pursuing this related course, especially as the students were well aware that the best man in the descriptive geometry class was their instructor in French. This cooperative work also served other purposes. It was a great stimulus to me, the instructor of the descriptive geometry class, to have a trained student before me who was a close observer of methods and seeking the maximum of instruction for the minimum expenditure of time. He was an excellent example to the class, in that he, having had no engineering training or preparation such as was required of the remainder of the class, easily distanced the best student, with not more than two thirds of the effort. This experience impressed me with the importance of the advantage to be derived from visits of this sort by members of the teaching staff. Mr. Hayden has since annotated for class use an elementary French treatise on descriptive geometry. This will be in readiness for our next years class, which will read it while pursuing the course in descriptive geometry. As the special vocabulary of the subject is limited, and as there is no great variation in the theme, only a limited time will be given to it.

Here are some of the observations of Mr. Hayden on his experience in teaching French to engineers:

The reading of scientific French should be limited to elementary subjects which are easily comprehended and are being studied at the same time, such as elementary physics and mechanics, surveying, and descriptive geometry. The chief value lies in the mathematical accuracy of rendering which enables the instructor to prove the necessity for accuracy of expression in a convincing manner. It is one of the best methods of teaching English. Again, this correlation of the French and technical courses is a dignified and legitimate method of increasing the popularity of the subject and enables the student to obtain a view point outside of his native language. It is not necessary that scientific reading be taught by an engineer, but it is very important that the teacher should be familiar with the subject read.

Of course all that has been said with respect to French applies equally well to German, but it has chanced that our experience has been greater with French.

The correlation of the English and technical courses is even more interesting because of the greater extent of common ground. In order to obtain the best results it is important that the department of English be administered by the engineering school, a separation of the classes in letters and science being made. The engineering student needs a special training in technical English: He needs to do elementary work in a somewhat different manner to produce results commensurate with those of the candidates for the A.B. degree: He needs to approach literary work in a somewhat different way to obtain the best results. Our department of English is not conducted by men who have had an engineering training, but by those whose education has been entirely of a literary character. The success which they have attained is due to their appreciation of the needs of the engineering student. I will quote briefly from Professor Earle's statement concerning these differences as brought out by his experience with the engineering students at Tufts. He says in part:

The engineer, as we find him, is fully as active minded, fully as original a thinker as the A.B. student, but:

1. He has less command of expression and of literary appreciation.

2. He is naturally not so much interested in languages and is not taking collateral language study.

3. It is not usual for him to have had much of that invaluable training which is obtained from a proper study of Latin and Greek.

Therefore he needs to be treated differently in order to obtain the best results of which he is capable. To this end his English should be expressly a training and he should be made to realize that his defects in expression are largely due to inaccurate thought rather than to infractions of grammatical principles: That he should be led to discover these defects, to define them and to remove them. Again, he needs training in the writing of technical papers. General composition and practice in writing is not enough. His case is no different from that of the man who is writing legal treatises, sermons, histories, dramas, or poems. Instruction in technical exposition is specially necessary, for unlike all other forms of writing it has been little studied in school or out of it. This form of composition is difficult judging from the daily experience with classes in this subject. Finally he needs to approach literary work, both creative and appreciative, in a different way from the A.B. student.

Serious difficulties stand in the way of the engineer who takes this work wholly with candidates for the degree of A.B. He is discouraged because the work is designed to call for qualifications which he has not, rather than for those he has, and he feels that he cannot compete successfully with the academic student. Fearing to betray ignorance which would seem inexcusable to others in his class, he does not ask the questions he would wish to. (This was suggested as an important point by a member of the sophomore class.) He is inclined to think work "in the other department" not an organic part of his course, not necessary, and therefore of decidedly secondary importance.

Literary work to have real value to the engineer must not be a part of a general course in literature, but must be a part of the life he is living and is to live. Even in his undergraduate life the demands for a great variety of literary work are present, and he must be trained to meet them in an adequate manner.

As regards the cultural value of academic courses Professor Earle says:

''Culture is not something to which one needs to be exposed: or something to be added to a course which would otherwise 'leave the gates of true education forever closed,' but the result of the way in which all the work is given the student, and above all the result of the way in which he takes his whole course. The engineering student has already settled down to special work so that he is no longer, as the A.B. student should be, in a position to obtain a broad view of literature and to love it simply for its own sake. To be broad he should not try to leave his special field and seek a better, he should learn to see his work as it is, in itself essentially broad and worthy. The engineering course has no place in college unless it is as broad for the young man whose interests have turned toward applied science as the academic course is for him who inclines to literature, philosophy, or art; but that breadth cannot be for such students unless the whole course has vital unity.''

One of the interesting results of this movement at Tufts is in the increase in contributions to the Tuftonian, the only purely literary publication of the student body. Until very recently the engineers manifested no interest in writing for this magazine, but during the past year the engineering students in competition with those in the A.B. course have contributed more than 40 per cent. of the prose articles and this percentage would have been much increased had it not been that much of the manuscript was rejected without being read.

An excellent illustration of the interest manifested in English courses was the petition of a large class of sophomores to have a half year course continued through the year. In order to have elected this course most of the class would have been forced to choose between it and a course in surveying. As it was not expedient to continue the subject through the year several of the class elected a course on "Poets of the Victorian Era," given in the college of letters. English is now being elected to a considerable degree by juniors and some by seniors.

Besides the regular course of instruction by themes, conferences and recitations the freshmen listen to several lectures by members of the faculty and others not connected with the school, who speak on subjects related to the assignment for themes: but these speakers are instructed to emphasize the importance of good expression and clear thinking as related to their own profession or business.

We are laying more stress on the English work of all the departments and trying to impress the student with the importance of writing well on all occasions. Our course in pattern-making given in the freshman year requires considerable descriptive work on the part of students. The graphic part goes to the teacher of drawing for the criticism of sketches and the written portion to the English department. Some of the tests in the pattern-making course are given as a part of the English course.

But we never shall meet with the desired success in English until the teachers of our engineering schools cooperate to the extent of considering their first duty to be that of a critical examination of the ability of their students to express themselves clearly, briefly, and in acceptable form, and to practice this on all occasions, in the class room, the descriptive theme, the written test, or examination paper.

Is there any cooperation more needed than this?

THE PLACE OF MODERN LANGUAGES IN THE CURRICULUM OF THE SCHOOL OF ENGINEERING.

BY ARTHUR S. WRIGHT,

Professor of Modern Languages, Case School of Applied Science.

The special work of the engineering school is to train for professional efficiency; but the measure of professional efficiency is dependent upon the character and ideals of the man. The new education, as the old, will be judged by the quality of manhood it helps to create.

Society needs men—men who think quickly and accurately, who feel strongly and generously; men of sound judgment and catholic temper; men with a fine sense of personal and professional rectitude; men who, as Governor Hughes said the other day, are to be "trustees of the future of a great country." Rare men are these, the product of native endowment, of home environment, of the education of school and of life. No institution may send forth a large percentage of such, but every institution should try to.

Much depends upon the curriculum; more depends upon the teaching force. Boards of trustees determine the latter; faculties the former. The boards have done their part well; the faculties are trying to do theirs. Though the new schools are utilitarian in aim and method, studies which contribute to breadth of culture have found their way into the curricula, and among these, foreign languages. Their introduction has been based upon a conviction of their worth. They are classed among the humanities, the pursuit of which contributes to a true idealism. Moreover it is believed that the foreign languages can be used as tools in professional work. But there are no fetich worshippers among the new schoolmen. The schools of science have a new cult: there will be little hesitancy in casting out dumb oracles. Foreign languages must submit to the same test as other branches of learning—that of efficiency.

There can be no question that there is a feeling among leading exponents of the new education that the study of French, German and Spanish in our technical schools has not accomplished what was expected. Let me quote the words of two of them, the first an educator of high rank.

He says: "German and French have been assumed to be not only of great value as culture studies, but to be tools in the hands of the students as well. As a matter of fact, they have generally served neither purpose and have simply added a load to the students' work. The study is continued in an intermittent way for two or three years, by which time the student has obtained the merest smattering of the language. Modern languages, as they are taught, have added almost nothing to the cultural side of the curricula of our schools of technology, and little to the technical preparation. They do not to-day justify their place in our curricula."

The second, a consulting engineer, of foreign birth, writes me as follows: "As far as I have observed, the language teaching in schools produces very meagre results, in no proportion to the cost, effort and time of teaching. The only change I would suggest is the total abolishment of the fad, and advising pupils who can afford it to take a year or two at a foreign technical school for rounding off their education there.''

Desiring to know to what extent this distrust of the efficiency of modern language instruction in technical schools is shared by the engineering profession, I sent out recently a circular letter to 116 engineers, requesting an answer to the following five questions:

1. Should a well-trained engineer be able to read the technical journals and treatises of at least one foreign language?

2. Which foreign language is of most value to the engineer and why?

3. Can a foreign language be so taught in an engineering school that the student will be able to read its technical literature?

4. What should be the primary end of instruction?

5. What changes would you suggest in the present methods of instruction?

About one hundred of my letters were addressed to members of this Society; the others to engineers wholly engaged in the practice of their profession. The response was far beyond my expectations. Of the 116 addressed, 95 answered. Many took pains to set forth their views in detail. I was astonished to find that practical engineers had given so much thought to the subject, and delighted to discover so generous an appreciation of the value of language study. Many of the suggestions were practical and I should like to quote them at length—indeed I should like to quote whole letters—but the limits of time permit only a summarization.

The first question I regarded as crucial, and as presenting the main issue. Of the 95 answering it, 70 gave a categorical "yes," or an equivalent, as "most decidedly," "certainly, two languages"; 6 answered "no"; 17 "desirable" or "advantageous"; 2 were indefinite. Let me quote the words of one prominent engineer, not engaged in teaching, as indicative of the general tenor of the answers: "I belive it is almost imperative for an engineer, in order to be successful, to understand foreign languages, at least sufficiently to enable him to read technical journals and books."

Of the 88 who answered the second question, 61 think German the important language; 8 others regard it as the most valuable for certain lines of engineering, French or Spanish for other lines; 6 have no choice between it and French; 5 vote unqualifiedly for French, 3 for Spanish; 5 are indefinite.

Sixty-nine believe that foreign languages can be successfully taught for practical ends in the engineering school. Three answer this third question with a "no;" several feel that the results sought are not, but might be, attained in their institutions; the others give no opinion. The answer of Professor Franklin, of Lehigh, is significant: "I think that our Modern Language Department accomplishes this result, but that the ability is soon lost because our technical departments do not keep the men at the thing during Junior and Senior years." Of this I shall have more to say later.

Question four: "What should be the primary end of instruction?" was indefinite and the answers were indefinite. Let me quote a few: "To be able to tap promptly the great knowledge that such foreign languages convey;" "to understand the people whose language it is;" "for its cultural value;" "usefulness, followed by cultural value as a close second;" "to speak and read;" "for cultural value and the assistance it renders in the use of the native tongue." The answers, it will be seen, are varied, but the large majority make the primary end, the ability to read technical literature. President Drinker writes: "We think here at Lehigh that the main end is the acquisition of a reading knowledge of technical journals, and I think that courses can be profitably planned to that end."

I can not incorporate in this paper the suggestions made under question five for changes in method. I may quote a few: "remove the subject from the curriculum or devote much more time to it and produce results;" "require, as rapidly as possible, a general college course with language training as a requirement for entrance upon the professional engineering course;" "require at least two years of one language for admission and teach that language two years in college;" "use a phonograph;" "the use of textbooks in the language taught, by the professors of engineering;" "employ German engineers to teach the language;" "use the natural method;" "teach your student to understand the people whose language they study;" "abolish the fad."

Without quoting further, I shall give a few inferences which I think may be fairly drawn from the correspondence:

First, that the intrinsic value of the foreign technical literature is so great that the engineering school should train its students to make use of it.

Second, that the Germans are so far in advance in research work and so prominent in the practical application of their results that their language should be given the first place.

Third, that it is better to teach one language well than it is to teach more than one insufficiently.

Fourth, that the main end of instruction should be facility in the use of technical literature.

Fifth, that the engineering departments should cooperate more fully with the language department so that the work may be made more efficient.

It has seemed to me that it might be profitable to present in tabular form what is actually being done in foreign languages in our schools of engineering. I am a little wary of bringing statistics before a body of men so dominated by mathematical instincts as this Society presumably is. I therefore bespeak your very generous consideration. My statistics were compiled from catalogues and an extended correspondence with the professors of modern languages and were in each instance finally submitted for correction to a teacher of language in the institution in question. While some failed to respond, the majority corrected or corroborated the figures submitted. The statistics are not absolutely correct, but I trust that they may be instructive and not less accurate nor more confusing than the catalogues of the various institutions.

The courses in 46 institutions have been tabulated. A few were omitted because the statistics were indefinite. Under the first main heading, "Units of Preparation," are given the years of work in the high-schools, a "unit" being defined as "a course of five periods weekly throughout an academic year of the preparatory school.'' We should bear in mind, however, that while this is the standard of the Carnegie Foundation, many institutions devote only four periods weekly to a study, so that the preparation is less than that indicated.

Let us examine the columns in order: Column one, headed ''German'': four institutions only—Case, Harvard, Massachusetts and Pennsylvania—require German; Princeton permits Latin as a substitute; Stevens makes it optional.

Column two: three institutions—Harvard, Massachusetts and Stevens—require French; at Princeton Latin may be substituted.

Column three: six require either German or French; Stanford makes them optional; Union and Wisconsin permit Latin as an option.

Column four: nine require either German, French or Spanish.

Column five: sixteen require ancient or modern languages; one, Illinois, makes them optional.

Surely here is diversity with a will! Educational individualism runs riot! A survey of the columns reveals numerous points of interest. I shall call attention to but one. Engineers regard German as *the* important language and yet only four schools require it for admission. If we want German, why not ask for it? Why not encourage the high-schools to do some of our work for us? Up to this year at Case, we have required but one unit of high-school preparation in German, and many of our students have come to us with only the one year of preparation. We now require two units. I have just examined eighty of the entrance papers in German, and find that the average time of preparation has been two and a half years in the high-schools. If German is not required for admission, two years of from eight to ten semester-hours each should be devoted to it in college.

If both French and German are to be required, French is a logical option; but to permit Spanish, Latin or Greek is to throw the whole burden of modern language instruction upon the college. This is what most institutions do, with the result that students either do not secure proper training in French and German, or that time is taken from technical studies.

Let us pass to the second main heading: "Semester Hours College." We note again the same lack of uniformity. Tulane and Union seem to have the same courses, though their entrance requirements are different. In general, no two of the forty-six institutions have, I believe, the same entrance and college requirements. Eighteen institutions require no modern languages of their students in the general course. Others require so little that satisfactory results must be impossible. This applies as well to those colleges which make French or German a subject for admission, but do not require its continuance in college. We may further add to the list of those insufficiently prepared, students of institutions which, like Columbia, Cornell and Harvard, require the languages for admission, but do not teach them.

The data under the heading: "Total Semester Hours, Preparatory and College," I have printed simply for the sake of comparison. The assumption has been made, arbitrarily, that one unit of high-school work equals five semester-hours. In view of the three-quarter-hour periods, the results will not be far from right.

First column: note that only thirteen institutions *require* in college, German of all students. The "maximum German" column is hardly more satisfactory. I regard the minimum satisfactory requirement in German as two high-school years, plus eight semester-hours in college, or, if the work is all done in college, sixteen semester-hours. Few of the institutions devote so much time to the subject. Pass to the second heading, French. French needs one year of study in high-school and from two to four semester-hours in college for science reading; it receives far less in most cases. No engineering school requires Spanish; most of them offer it.

The method of computing the last column is indicated in note "D." It gives the minimum time devoted to foreign languages, in class, in high-school and college.

While the table may not be of great value to the members of this Society, I think it will be suggestive to the teachers of language in engineering schools.

Before discussing the aims and methods of our modern language instruction, permit me a few words regarding our education in general. The quality of the scholarship and the ideals of life of our students depend upon the personality of *all* the teachers and the way they teach. If you technical men, who are the very large nine-tenths, teach for practical ends and neglect the cultural, and if we language men, who are the very small one-tenth, teach for cultural ends and forget the practical, we shall get narrow-gauge results. If the technical men will broaden out just a little and the language men narrow down a good deal, we shall secure a broad-gauge scheme of education into which the language courses will fit.

Engineering education has set itself in bold opposition to the traditional contempt for utility and has given the word a new value. It has helped men to see that knowledge attains added dignity when made useful to man, promoting his comfort, security, opportunity. We have come to realize that calculus is not less a disciplinary subject when so taught that a student may use it in bridge building; that physics, mechanics, chemistry, do not lose in intrinsic worth because in acquiring them one learns to use them in the solution of engineering problems, the solution of which advances civilization. As Professor Marston said two years ago before this Society, "there is no reason why a study of engineering history may not have as much cultural value as the study of general history, nor why the study of railway administration may not be as valuable training as the study of some text-book on political economy." Utilitarianism, far from being the reproach of engineering education, is its distinction. The laboratory method has tremendously stimulated the intellectual activity of man. The widening and deepening of the world's knowledge has been commensurate with the practical application of that knowledge.

The literary college has, with some measure of consistency, stood for idealism. But it is an arrogant assumption of the classicist that his methods only lead to culture. History, philosophy, literature, do broaden the horizon, quicken the sympathies, give mental poise, impart—sometimes—that intangible something which we call culture. But when we trace culture to its source, we find always, a personality, not a subject. It is the teacher, not the subject, which kindles enthusiasm. The study of the humanities may leave a man without any real humanness. The three college teachers who contributed most to my own idealism taught, the one pure mathematics, the second natural science, the third engineering. Fill our chairs with men of breadth, of kindling enthusiasm, men who love knowledge for knowledge's sake and boys for boys' sake, and we shall send forth graduates who may stand side by side with the best from the colleges of liberal arts.

The modern languages (including English of course) physics, history, economics, are your so-called liberal studies, but they will not produce liberal men. The spirit of the institution determines the spirit of the student and the alumnus. The professors of engineering can not shift their culture burden to the shoulders of the teachers of language. The modern languages must not be a graft on the curriculum; they must simply contribute toward making all the fruit more perfect. The cultural value of language study, let it be borne in mind, does not come until the language is largely mastered. Up to that point, the study is disciplinary, and the discipline is not essentially different from that of other branches. If then we were to expect large cultural results, the scope of the studies would need to be greatly increased. This is impossible owing to the limits of time and the pressure of the purely technical studies.

Let us then, so far as German is concerned, rivet our attention upon technical literature. This is the goal and one worth striving for. You all know that in your various departments there is a wealth of technical literature in the German language which is of great value, and much of which is indispensable. Two facts, often noted, I may be permitted to recall your attention to: first, that the leading men of science in Germany are University educators, men who publish their investigations; second, that the close relation between manufactory and laboratory results in a practical literature is of great value to the engineer and technician. To make this literature accessible to the young engineer is the problem. Whether it is accessible or not *may* determine his efficiency, his rank, his career. No one may tell when he may need something from a foreign source. Months of time may often be saved by a legitimate use of what others have accomplished in a German laboratory. A professional translator is, in most instances, impossible, and his translation often needs translation. What is needed is the ability to make first-hand use of the periodic literature. Can such ability be acquired in a technical school? Without any question, given proper methods and a course of fair length. About one point we must be perfectly clear, however, the work can not be accomplished in the preparatory school. The style and vocabulary of technical literature must be acquired through special instruction, in courses adapted to engineering students. This fact is being recognized in institutions where thought is given to the subject. Dean Cooley, of Michigan, writes me as follows:

"In this university the modern language work for the engineering students is in charge of our own department, being entirely separate from the literary department. We are, therefore, able to give the modern language the necessary direction along engineering lines and our instructors live in an engineering atmosphere. We study the language for its technical use rather than for its literature. The separation from the literary department was the most important step we have taken in this branch of instruction."

I am convinced that this represents the trend of thought and effort in the engineering schools. At Tufts, where a consistent scheme of language instruction has just been worked out, the courses are largely distinct from those in the college of arts. The University of Minnesota has just introduced two years of language study in its engineering courses. Professor Constant, of the university, writes me under a recent date: "I would suggest special instructors for the engineering classes. Instructors in the academic classes are generally interested in the literature of the language and have little sympathy for, and interest in, the needs of the engineering students. These, in turn, do not enthuse over what seems entirely apart from their engineering interests. But the right kind of men in the engineering schools can change all this. There is no reason why engineering students should not have a vital interest in the study of a live modern language. I doubt if it is change of method so much as enthusiasm and sympathy with engineering students that is needed."

This leads me to speak of a feature of the work which I consider of great practical importance, the cooperation of the technical departments. The responsibility for the attitude of indifference or antagonism of the students toward language study rests upon the technical men. They should uphold the dignity of the language department; they should help to make the work effective. This is suggested by several of my correspondents. Let me quote Professor Scott, of Texas University: "Require, after the regular course, a further year's work of three hours a week under a man who is able to give instruction not only in the technical literature, but who is, at the same time, sufficiently interested in engineering to make a wise selection of technical literature to be studied, giving the student, at the same time, along with the knowledge of technical terms of the language, some knowledge of an engineering subject."

While this plan may not be feasible in most institutions, the idea underlying it is a good one. I would propose, instead, that in each technical department, one hour a week during Junior and Senior years, be devoted to a study of foreign periodic literature. In the departments of Chemistry and Mining Engineering at Case, such classes are conducted, though in the latter the time is partly devoted to English periodicals. Other departments are considering the organization of similar work. The mining class is for juniors and seniors. The twenty available journals are assigned to the different students who report on the contents and give a written report of the most important items. Each student is allowed four minutes. Discussion is encouraged. Such a seminary should be organized and participated in by the head of the department, but might be conducted by an instructor in the department. It would seem, moreover, that language instructors who devote their lives to teaching in a scientific school might be sufficiently imbued with the spirit of the institution to participate in such a class. The use of periodic literature, which should be begun in the course, would thus be continuous throughout the three or four years. After such instruction, I am convinced that our graduates would subscribe for and read the technical journals pertaining to their various lines of work.

What has been said hitherto applies chiefly to German. The technical literature of French offers no special difficulties to one who can read other French. Our courses may be planned along the lines of those pursued in the literary college, with perhaps two semester hours devoted to the reading of science texts and periodicals. This should be supplemented however, by the study of periodic literature in junior and senior years.

Spanish should be an elective in the senior year. To teach it to our students as a whole, or to make it optional with German or French, is illogical. The presumption is that many of our students go to Spanish-speaking countries. The fact is that very few do. Out of 743 graduates of Case School, only seven are in territory where Spanish is the native tongue.

As the language offers almost no technical literature of value, the aim and method of instruction should be quite different from that in German or French. The study should take a practical trend.

The course should offer abundant exercises in conversation, dictation and correspondence. A good feature of the correspondence would be the interchange of letters with Spaniards. Academic dignity could be given to the work by making a study of the life and institutions of Spanish-speaking peoples. If, as I have suggested, Spanish were taught as an elective in the senior year, the classes would be small and the so-called ''natural method'' could be used to advantage.

I am sure that it will be a disappointment to some that I have said so little of the cultural value of language study. In justification, I may say that I am not treating that side of the question. I am convinced that the modern languages courses in our schools are in jeopardy. Several of my correspondents write me that they are considering eliminating them from the engineering course. I feel that the time has come for the language studies to prove their *raison d'être.* We language men, in adjusting ourselves to our environment, do not need to give up all our ideals. Any teacher, who is himself cultured, will find opportunity to daily touch points which stimulate thought, broaden the intellectual horizon, kindle the imagination. From a course of reasonable length purely literary work need not be excluded though the main emphasis be laid upon the language of science. There will always be time for rapidly reading a classic or two. I read Faust with my class every year.

But aside from this, it is possible, without serious loss of time, to introduce features which contribute quite as much to breadth as do courses that are purely literary. You will pardon me if I describe briefly what I undertake with my sophomore German class. It is my conviction that a modern language should always be taught as an expression of the life of a people and that the value of a language is directly proportioned to the greatness of the people it represents. Back of the German language is a great civilization. Our own language and institutions strike their roots deep in German soil. I prize the opportunity to help my students to an appreciation of this German civilization.

We first study the history of the country, and especially the history of the nineteenth century, tracing the growth of constitutionalism, the development of a national consciousness and the passing from national individualism to national unity.

We then discuss the geographical position, the resources and form of government of the various states; the grouping of states, the racial differences and the local economic conditions.

An analysis of the political constitution of the new empire follows: the nature of the federation of states, the legislative system of the empire as represented in emperor, chancellor, Bundesrat, and Reichstag, political parties, militarism, paternalism and municipal administration.

Finally, we consider the social, economic and educational conditions of the country, including such subjects as amusements, public utilities, wages, compulsory insurance, industrial, commercial and technical education, with special reference to the development of domestic and foreign commerce.

The students take notes, do collateral reading and pass examinations on the main features of the course.

I have a lantern in my rooms and an extensive collection of slides and photographs which add to the interest.

The aim of the course is to bring the students into sympathetic touch with the life of another folk and thus to counteract, in a measure, that provincial spirit so characteristic of the American youth.

I have not outlined this course with the idea that it will be adopted by others but simply to show you that it is possible in a practical course to incorporate features which have cultural value. Each language teacher must devise his own methods.

In conclusion, four things only are needed to put the work of the modern language departments on an equality with that of the technical departments:

First, enthusiasm on the part of the teacher and the conviction that there is a work to be done worth doing.

Second, the hearty cooperation of the technical departments.

Third, the careful editing of some good technical literature.

Fourth, a statement of principles by some authoritative body.

Some of the features which need determination are: the amount of work which the preparatory schools may be expected to do; the possible encouragement of language study in the preparatory school by crediting it toward the B.S. degree; the securing of uniform units and of measurably uniform entrance requirements; the relative value to the engineering student of the three languages taught; the ends to be sought in language study in the technical school; the time limit for each language; the correlation of the work with that of the technical departments.

When we shall have attained these things, we may hope that the modern languages, very demure handmaidens of a very royal mistress, Mistress Science, may no longer be merely tolerated, but raised to that full equality which is theirs by virtue of their charms and character.

EXPLANATION OF TABLE.

Note A.—A "unit" is a course of five periods weekly throughout an academic year of the preparatory school.

Note B.—A "semester-hour" (S.H.) is one recitation a week of college work for a half-year.

Note C.—In computing the "totals," one unit of preparation is arbitrarily counted as equal to five semester-hours.

Note D.—This column gives the minimum number of full recitation hours devoted to languages in preparatory school and college. The 45-minute periods of the preparatory school are changed to hours, one unit being counted as 135 instead of 180 hours. The year is reckoned as 36 weeks in preparatory school and college.

Note E.—Parenthesis indicate an elective.

[a] Special courses in German for chemists.

[b] Or Spanish.

[c] One or more additional units may be offered in language.

[d] French required unless offered for admission.

[e] Four units of Latin may be substituted for the requirement in either German or French.

[f] Or two units and two of Latin.

[g] Or four units of Latin.

[h] Modern languages required from students who have had opportunity to acquire them.

[i] Or two units of German and four of French.

[j] For students entering without a modern language.

[k] Only six S.H. required of well-prepared students.

[l] Six S.H. of physics may be substituted for either French or German.

[m] Two units of German or French must be offered.

[n] Electricals have 486 hours; mechanicals 558.

[o] Civils have fourteen.

[p] The two units must be in one language.

FOREIGN LANGUAGE COURSES IN SCHOOLS OF ENGINEERING.

Institution.	Units of Preparation.					Semester Hours, College.				Total Semester Hours, Prep. and Col.						Total S. H. Mod. Lang.		See "D."
	Ger.	Fr.	Ger. or Fr.	Ger., Fr. or Sp.	Anc. or Mod. Lang.	Ger.	Fr.	Ger. or Fr.	Ger., Fr. or Sp.	German.		French.		Spanish.				
										Min.	Max.	Min.	Max.	Min.	Ma x	Min.	Max.	
Alabama Univ.				1						0	5	0	5	0	5	5	5	135
Armour Inst.				2				(6–12)	(6 Sp.)	0	16	0	16	0	10	10	28	270
Brooklyn Poly.				2[c]		[a]			8	0	18	0	18	0	18	18	18	414
California Univ.					2–4	[a]						No required work.						0
Case Sch. Ap. Sci.	2					10	10[b]			20	20	0	10	0	10	30	30	630
Clarkson						5	5		(2 Sp.)	5	5	5	5	0	2	10	12	180
Colorado Univ.					2				6	0	16	0	16	0	10	6	16	108
Colorado Sch. Mines.					2							No required work.						0
Columbia			2[c]							0	10	0	10	0	10	10	10	270
Cornell (Sibley)			4[c]							0	20	0	20	0	0	20	20	540
Dartmouth (Thayer).				2[c]					6[d]	0	10	6	10	0	10	16	16	378
Georgia Sch. Tech.								12		0	12	0	12	0	0	12	12	216
Harvard (Grad. Sch.).	4[i]	2								10	20	10	20	0	0	30	30	810
Illinois Univ.					(8)	[a]		(8)				No required work.						0
Iowa State Univ.				2		[a]				0	10	0	10	0	10	10	10	270
Kansas Univ.					3				10	0	25	0	25	0	25	10	25	180
Lehigh			2			[a]		6–16	(4 Sp.)	0	16	0	16	0	4	16	30	378[n]
Maine Univ.				2		[a]			10	0	20	0	20	0	20	20	20	450
Mass. Inst. Tech.	1	1				0–6	0–6		(3–4)									378
McGill			3									No required work.						0
Mich. Univ.					2[c]				16	12	26	8	26	8	8	16	26	432
Mich. Col. Mines												No required work.						0
Minnesota Univ.					2				16[k]			Indefinite.						378

FOREIGN LANGUAGE COURSES IN SCHOOLS OF ENGINEERING.—*Continued.*

Institution.	Units of Preparation.					Semester Hours, College.				Total Semester Hours, Prep. and Col.						Total S. H. Mod. Lang.		See "D."
										German.		French.		Spanish.				
	Ger.	Fr.	Ger. or Fr.	Ger. Fr. or Sp.	Anc. or Mod. Lang.	Ger.	Fr.	Ger. or Fr.	Ger., Fr. or Sp.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
Nebraska Univ.........					2				(7–23)			No required work.						0
Ohio State Univ.......					4–6				8	0	28	0	28	0	28	8	28	144
Oregon Univ...........					2							No required work.						0
Pennsylvania State....					2	^{a}		12		0	22	0	22	0	22	12	22	216
Pennsylvania Univ...	2							12		10	22	0	12	0	0	22	22	486
Princeton........	2^{c}	2^{c}				6^{i}	6^{i}			6	16	6	16	0	0	16	32	378
Purdue..................			2			10			(2 Sp.)	10	20	0	10	0	0	20	20	450
Rensselaer...............												No required work.						0
Rose Poly...............				2^{e}		(2)	(2)	12	(1 Sp.)	10	14	10	10	0	1	22	24	486
Sheffield......			2			12	12		(7 Sp.)	12	22	12	22	0	7	34	41	702
Stanford			(4)									No required work.						0
Stevens..................	(2)	2				18			(4 Sp.)	18	28	10	10	0	4	28	42	594
Syracuse Univ..........				3^{f}						0	15	0	15	0	15	10	15	270
Texas Univ.............					3				12^{j}	0	15	0	15	0	15	12	15	216
Tufts College...........					2–9				6–16	0	21	16	21	0	6	16	36	288
Tulane Univ............					2	6	6			6	16	6	16	0	0	12	22	216
Union...			2^{g}			6	6			6	16	6	16	0	0	12	22	216
Virginia Agr.& Mech.									21	0	21	0	21	0	21	21	21	378
Washington Univ......					2^{h}							No required work.						0
Wash. Univ., St. Louis					2			9		0	19	0	19	0	0	9	19	162
W. Virginia Univ.....				2						0	10	0	10	0	10	10	10	270
Wisconsin Univ...			2^{g}						11	0	21	0	21	0	11	11	21	198
Worcester Poly...					4^{m}			9–13		18	23	18	23	0	20	23	28	414

DISCUSSION.

PROFESSOR KARAPETOFF: It seem to me that in order to insure success in teaching foreign languages in this country their knowledge must in some way be made a necessity. It happened this year that I conducted a special course in electrical design for advanced students. I told them that there was no book in English on a certain topic, or any good articles that I knew of, but that there was a splendid book in German. All of the men said that they had had some German in high school, but had never attempted to read a German book. I encouraged them to buy this book; they did so, and at the end of two months all of them could find in it what they wanted in calculation or construction. That was all that they needed. The book is provided with a great many illustrations, so that what they could not understand in the text they could find out from the illustrations. This brought to me the suggestion that instead of teaching German or French to engineering students as a special course, why not combine it in a natural way with one of the regular courses, for instance the course in physics or descriptive geometry, as was suggested in another paper. Instead of adopting an English text-book on physics take a French or German book and recite in English. Do not mention French or German in the classes. The students will then have to study them and will see the necessity for them and their usefulness.

There will be some difficulties in this plan that will have to be arranged for. I bring this matter up as a suggestion especially suitable, I think, for small colleges.

SECOND DEGREES FOR GRADUATES OF ENGINEERING COURSES.

BY W. F. M. GOSS,

Dean of the College of Engineering, University of Illinois.

As a background for the presentation I wish to make, I would call attention to the manner in which present practice relating to the baccalaureate degree for engineering students has grown up.

Twenty-five years ago a number of the older institutions in this country gave, at the end of a four-year course, the professional degree, mechanical engineer, civil engineer, etc., and a number of these institutions continue that practice to-day. In the development of many of the state colleges of engineering, it was thought best to avoid giving at once upon graduation this full professional degree, and some in their desire to compromise gave for a time the degree of bachelor of mechanical engineering, bachelor of civil engineering, etc., which was regarded as a preliminary degree to be followed in due time, and without very much additional work, by the full professional degree. After a time this process gave way to the practice of making the baccalaureate degree, bachelor of science for all graduates of engineering courses; but in many state institutions the idea that this degree for engineers, like the degree of bachelor of engineering which it has supplanted, was more or less a preliminary degree has continued. It has commonly been assumed that as soon as the holder of the baccalaureate degree had gained professional experience, the professional degree such as mechanical engineer, civil engineer, etc., should be conferred. This view has found expression in the catalogue statements of a considerable number of institutions, which, in general, provide that after three years of successful practical experience, the completion of a satisfactory thesis, and the passing of an examination at the university, the professional degree of mechanical engineer, civil engineer, etc., would be given following the degree of bachelor of science in mechanical engineering, civil engineering, etc. This practice is so common among the institutions we represent that I am sure that it is well understood by all. The point I wish to emphasize is that we have come to regard the degree, bachelor of science, when conferred as the baccalaureate degree upon engineering students, as a preliminary degree, and we make it comparatively easy for some graduates to secure the advanced professional degree.

Now going to the other side of the problem, the colleges of liberal arts have, in the main, declined to give the degree of master of science for non-resident work, that degree being given only at the end of one year of resident work. This fact has led to some confusion in institutions where advanced degrees are given for work both in engineering and in liberal arts. My first point is therefore that it will be well to recognize and admit the fact that under the conditions described, the professional degree of mechanical engineer, civil engineer, etc., is not the equivalent of the degree of master of science given in course. I do not mean that it means less or more than the degree of master of science, but it is based upon a different series of facts.

Building upon this conception, the institution with which I am connected has decided to make a plain statement containing the facts to which I have referred, and to grant both professional degrees and master's degrees to graduates of the college of engineering; the professional degree to be given graduates of the college of engineering after three years of satisfactory professional work, and upon the preparation of a satisfactory thesis, covering the professional experience. It also grants to those who hold the bachelor's degree in engineering, the degree of master of science in mechanical engineering, civil engineering, etc., after one year of satisfactory resident work. This practice frankly acknowledges the difference between the two classes of degrees; the academic degrees stand on one side for resident work, and the professional degrees stand on the other side for professional experience and attainment.

I shall be very glad if later there can be some discussion as to the view of the members of the society concerning such a practice.

Note.—After the reading of the paper, the subject was referred to a Standing Committee for study with the request for a report at the next annual meeting of the Society.

SCHOLASTICISM IN ENGINEERING EDUCATION.

BY JOHN PRICE JACKSON,

Dean of School of Engineering, The Pennsylvania State College.

Scholasticism, as the author interprets, when applied to a system of education, means a character training which is pedantic, based upon and developed along lines purely conventional, and lacking adaptation to the conditions of civilization, that may at the time prevail. Schooling of this kind cultivates the mind without reference to utility. Such systems were especially admired and prompted by a school of early German philosophers, among whom was numbered the famous Kant. Some centuries ago, early in the formative period of our modern system of civilization, when the religious orders were educated, intelligent and controlling factors in the government and leadership of the world, it became necessary that opportunities should be given the novitiates to fit themselves for their various responsibilities and avocations. As the most important function these men had to perform, of a public nature, was leading devotional exercises—mostly in Latin, which added to the mystification, awe and humbling of the masses of the common people—it was eminently practical that the education, made available to those aspiring to become religious leaders, should include Latin as a major, with church architecture and art, history and mathematics as minors—to use the technical phrases of more modern education. Therefore, even at that time, education supplied a practical and necessary preparation for life. A few centuries rolled by and this education, on account of the changing conditions of civilization, due to the development of higher thought among the whole people, became unfitted to its purposes; as much so, indeed, as have the spear, sword and bow of the same time become incapable of adaptation to the uses of war, because of the growth of more modern weapons.

Again, at a later date, including much of the last century, the classics, in connection with some other languages, mathematics, natural science, etc., were adopted into the college curricula in a way supposed to prepare leaders of another type, namely, the lawyers and writers. Thus again, higher education took—in the minds of many—a practical cast, or one which would directly fit men to take their places properly and usefully in life; but as the decades passed by, and industrialism grew, such education, however well fitted it might have been for certain narrow professional classes, became, in many cases, worse than useless for the great masses of those who were to become leaders of the more modern, complicated, industrial organizations of the latter part of the last century. Thus, the systems of education—persisting with a vitality surprising—became filled with scholasticism, or useless elements, which were pursued by those seeking *culture and polish* rather than preparation for useful careers.

In the latter third of the last century, under the inspiration of the Land Grant Act of 1862, which was the first strong act of our national government making for an education which would properly fit industrial classes engaged in agriculture and mechanic arts, not excluding other professions, and through the wise foresight of a few educational dreamers, sprang up a system of technical and engineering education, which met the conditions of civilization at the time; and was, in this country, so well adapted to its purpose, and so satisfactory, that it was a potent influence in causing our nation to take a leading place, among the nations of the world, in commerce and manufacture. At this time, however, questions are beginning to arise: Does our modern engineering and technical educational system show symptoms also of growing scholasticism, as did its predecessors? Is it being modified and corrected as rapidly as is necessary, considering the kaleidoscopic changes which are going on in the conditions to be met by the young graduate who is to enter life? Are there not courses of study, developed in great usefulness between 1860 and 1890, which are becoming more or less antiquated? Should we continue, in detail, the educational policy of recent years, or should we adopt some of the numerous suggestions for improvement?

Before answering these questions, it is well, for a moment, to look aside at our lower grades of education, which have during the past year or two received such careful consideration from educators, and ask the same questions regarding them. Do the boys, who on account of environment, or natural ability, are only able to pass through the preliminary grades of our public schools, have a preparation which is best fitted to make them useful? Or should they, in addition to the three R's, be given a satisfactory training in some trade, or life work, however humble, which would enable them to perform their foreordained labors with less of the biblical "sweat of the brow," and more happiness to themselves, and those dependent upon them? Likewise, are our boys, who for the same reasons leave their educational careers at the end of the grammar school, able to enter the counting house, commercial establishment, transportation organization, and take petty foremanships in the factory, or the positions of skilled labor, in a way to best subserve the interests of humanity? In like manner, are the high school graduates properly trained for their proper grade of work?

The consensus of opinion among educators today is, I believe, that our public school system has become more or less scholastic; not so much because of what is done as because of what is not done. Thus: the small boy who is able to go to school from six to eight years, should sometime, somewhere, be able to get something more directly in the nature of a useful implement for winning bread, than merely the three R's, as indeed should every boy of every grade. Trade schools, manual training schools, and similar institutions are springing up in quite large numbers to perform, in connection with our public school system, this beneficent and necessary supplementary service. Such additions to the common school education—with closer or more intimate relations between the industrialists and the teachers—may be a solution of our present needs in the way of educational modifications.

To return now to the question of the education of the engineer and as to whether it is becoming impractical and unsuited to modern conditions; a problem is found similar to that of the lower schools, and also one difficult of solution.

Consider a few instances where doubt as to policy may exist; for example there is a subject which has been dealt with largely in these meetings without any resultant uniform agreement—namely, the amount and character of liberal studies to be given in an engineering course. When questioning the propriety of large expenditure of time upon such studies, which might be used in inculcating principles of natural science directly applicable to the industries, the character of the teaching and its effect upon the student should be carefully considered.

If a course of about two years, of about four periods a week, is given to such liberalizing studies, using the older treatments of history, political and social science, etc., there is reason to believe that the time is not devoted in the most advantageous manner; but if such time be used to help a young man to understand also present industrial conditions, and to aid him in handling men who are either in the ranks of labor or capital, then I should say that the time is none too long.

Consider history, which is now and then taught in engineering courses, as a liberalizing study. Courses in this subject, in almost every case, dwell in detail on the political and religious conditions of the world in its various stages, as well as upon some of the more noteworthy social and racial movements and influences; but for some inexplicable reason the great scientific and industrial developments of the world have been largely neglected by the historian. (To be fair, however, it is necessary to say that there is a new school of historians coming into prominence, which is endeavoring to rectify this weakness.) We are told, in detail, in the texts of Napoleon and his conquest of the world, ended at the hands of the stubborn Britain; we may possibly, learn from the same source, the menu of George II.'s breakfast; or find the character of the clothing worn by the stiff-necked Queen Elizabeth; but it is little indeed that we get from the historian concerning such giants in the world's history as Gilbert, Newton and Faraday. Is it not true that the present conditions of civilization were more affected by the achievements of such men than by the conquests of Alexander, or even by the magnificient genius of Cæsar? What of the modern steam engine—developed to usefulness, amid scoffing and ridicule, by James Watt—as a maker of history? History has shown that, along with the growth and accumulation of scientific knowledge, there is a natural growth of industries and social organisms to fit and utilize the knowledge of nature as it becomes available.

It is not well to belittle the desirability of studying political, religious, sociological, and literary history; even, possibly, to learning the exact genealogical tree of Louis XIV. to one of his great-great-great-grand-aunts, that is, if some potent historical cause or effect is made apparent thereby. Why not, however, give our young engineers in college—when they have reached a mental and physical development which will enable them to fully comprehend proper presentation of history—a course presenting *all* important facts correlatively, which have gone to the making of the conditions to be met by these young men when they leave their college quarters.

Having completed such a survey of the world of man's making, possibly taking a year, would it not be well to give a second year to the study of political economy, government, citizenship, etc.? Here again the old stereotyped texts suitable to the conditions of twenty-five years ago—books on constitutional law, or government, and political economy of that period—do not meet the conditions of today in many vital particulars. New and more suitable treatments, which have broken away from traditions are needed.

Useful lines of thought, which could well be presented to senior students in engineering, are suggested by the list of some of the course titles advanced by the Department of History and Political Science of The Pennsylvania State College, to fill the need of the modern industrial student; thus: "Labor problems, principles of economics, constitutional government in the United States and world, commercial and economic geography, political parties, municipal government, international law, business corporations, world politics, railroad economics, colonial dependencies, agricultural economics." Some of these subjects would not necessarily be in the proposed major course of one year; but the list shows a practical grasp of some of the problems which are facing the men whose duty it is to supply leaders capable of economically wresting raw materials from the earth, converting them by manufacture to the comfort and use of man, transporting them, and finally ditributing them among the people of the world by a facile system of barter.

I am personally strengthened in my belief regarding the importance of these subjects as a material part of undergraduate engineering courses by the attitude of President Edwin Erle Sparks, of the institution named before, who is a recognized authority on industrial history, and who, in the main, I am led to believe, supports these arguments.

Is it not possible that Professor Perry's contention, that we are not sufficiently well applying our mathematical principles in the teaching, worthy of some consideration? Indeed, is it not possible that less ground should be covered with more thoroughness, and that practical seminars of applied exercise should be carried on parallel with the recitations and lectures? Likewise, is there not even yet the tendency in shop work and drafting toward the making of conventional joints and similar pieces, and the drawing of geometric figures, etc., where the elementary teaching of shop and drafting principles could be better accomplished, and at the same time practical and professional spirit be developed, by making parts in the shops which can be joined together into a whole; and in the drafting room, by actually drawing from sketches, taken by the student himself, of completed mechanisms? Shop system, finance, and management should possibly be made more prominent and its importance should be more thoroughly understood by the student as he passes through the courses of the various shop departments. Is it not also a fact that in many institutions the preliminary physics and chemistry are not taught in the best and most intimate relation with subjects to follow, which are more directly termed engineering? Indeed, if the engineering colleges are not to become scholastic, should they not treat chemistry, physics and mathematics as engineering subjects, or on the same basis as dynamo machinery, steam engines, thermodynamics, structures, etc.? Will not the cultural phase be as great as if a different conception prevailed?

To come to the work of strictly engineering departments, is it not frequently the case, in spite of the exhortations which have been heard at this meeting, that there is a lack in the teaching of engineering humanities? I have spoken to you of what seems to be a desirable arrangement of history, political and sociological science, etc., but these scheduled humanities will in no manner relieve engineering instructors from one of their important duties, namely, the development of true, honest, professional spirit, in the students; teaching them to deal firmly, and at the same time humanely with those under them, to show obedience and respect to those higher in command, and to develop the characteristics of initiative, reliability, and accuracy.

Is it not possible to delete scholasticism by bringing both students and instructors into closer relations with the industrialists? May not one of the wise methods of doing this be to get a percentage of instructors directly, on leave of absence, from the industries? The author, last fall, suggested to the American Society of Mechanical Engineers that the industries and colleges exchange their younger staff members for limited periods. If this is done it will be of advantage on both sides.

Another method now being adopted by The Pennsylvania State College—in force in two instances—is to employ industrial experts as *"consulting professors,"* a new term of the writer's coining. Such men should visit the college with which they are connected possibly four times a year of a week each to deliver lectures, and also to advise concerning the curricula, methods, etc. These men should not be mere lecturers, but should be so identified with the college work that they can feel as deep a sense of responsibility for its success, as do the resident professors. Engineering experts may be expected to do this without great recompense.

The students may be given desirable training by industrial managers permitting them an opportunity to do summer work, to spend an extra year in the shop before graduation, to take student graduate shop courses—similar to many of the excellent ones now arranged—after graduation, or sometimes to take, simultaneously, college and industrial work, lengthening the course proportionately to the time spent away from college. (Professors Dugald C. Jackson and Herman Schneider at the Massachusetts Institute of Technology and the University of Cincinnati are, I understand, trying the last method.)

Suitable cooperation between the college department and the industry, of the nature suggested above, is undoubtedly necessary for the best work. Does the industrialist lack confidence in the new college man? If so, it is because he has neglected his duty in not taking a hand in shaping the policy of the college. The technical colleges are ever ready to place themselves under the guidance of successful practicing engineers when such men are willing to really give thought and time to educational subjects.

In this brief paper, are outlined a few sides of engineering education, which seem most nearly to fall under the head, in their present form and mode, of scholasticism. Already there is stirring a movement throughout our Society toward not permitting these conditions to continue longer, and already many strong minds are endeavoring to tune up our engineering educational systems to the functions they must perform.

Germany is by many recognized as a leader in solving the great problems of buying and selling, of economical manufacture, of ingenious catering to the wants of the world, and to the efficient industrial organization of her people. If this be the case, it must be that Germany is looking with intelligent eye upon the training her young are receiving, and has rooted out such scholasticism as has persevered, and is teaching the masses to serve well the industries of production, manufacturing and distribution.

It would be a thankless task to decry the old and advocate the substitution of the new as a policy, for the feeling of Goldsmith, who, "loves everything that's old, old friends, old times, old manners, old books, old wine," appeals to the human heart; but I am firmly convinced that history shows a tendency in educational systems to depart from the position of greatest usefulness to the people; and that, to prevent such a result—which is disastrous to human happiness and welfare—it behooves us to so continually modify the old, and add the new, as our knowledge of nature and life becomes more profound, that our young men who are soon to do the work of the world and to rule the world, may leave the hands of their trainers—the pedagogues—fit and trim to bear their part in the great innings stretching before them. Nor do any of the suggestions of this paper tend toward less cultivation, refinement of manner or thought, or appreciation of art—all of which are of such importance in the sum total of human happiness.

Discussion.

Professor Hibbard: I have brought with me some suggestions which I put into the hands of the students, to give them ideas as to how they may profit most by their summer's work, and I speak of them in connection with this paper—"Scholasticisms in Engineering Education." I believe that one of the strongest influences for the prevention of engineering professors indulging in scholasticisms is a body of students that will not accept scholasticisms, and if you have a body of students that has had from one summer to several years of sharp, practical experience, that body of students will not accept of scholasticisms. It does not take a very large percentage of students in a class to leaven the whole lump so that no professor will dare bring scholasticisms before them.

TECHNICAL INSTRUCTION IN HYDRAULIC ENGINEERING.

BY DANIEL W. MEAD,
Professor of Hydraulic and Sanitary Engineering,
University of Wisconsin.

For twenty-four years the writer has been actively engaged in the practice of his profession as a civil engineer, during which time he has devoted much of his attention to applied hydraulics. For the last four years he has occupied the chair of hydraulic and sanitary engineering at the University of Wisconsin, continuing however his professional practice during that time.

Prior to 1904 the writer had given no particular attention to technical education, although he had been greatly interested in the development of the professional subjects in which he had been directly engaged. He therefore accepted the position at Wisconsin with considerable doubt as to the adequacy of his training to properly fill it, but with a strong desire to work out, as far as possible, his ideals in the educational field of his own specialty.

It was understood that the writer should develop the department of hydraulic engineering on the lines of his personal ideas, which were fairly well understood by Dean Turneaure of the Engineering Department, and that such development should be carried to the extent that the importance of the department, or the demand for such development at the

University of Wisconsin, would warrant. It was also agreed that opportunities would be afforded for research work along hydraulic lines, the importance and necessity of which the writer appreciated from his own studies, experience and investigations.

Four years have elapsed since the writer began his work at the university. Many of his early ideas have changed somewhat and have been modified by his experience in the educational field. He began this work with a fairly clear appreciation of the difficulties that confronted him. He recognized the possible errors to which an instructor would be liable, who came from a field of practice into educational lines without previous experience. Such an instructor was likely to overestimate the real educational value of certain lines which might seem, from his practical experience, of importance and to underestimate the educational value of much that was taught in technical institutions which might seem to him of little practical value or importance to the professional engineer. He fully realized the fact, however, that the best technical education did not, or should not, consist in a knowledge of disconnected practical details which might be absorbed by the student without knowledge of the scientific basis on which they must directly or indirectly depend. He was also strongly of the opinion that a theoretical education having no direct bearing on the practical problems of the engineer, while of value in an educational way, would better be replaced by the technical studies which had a direct relation to the actual problems of the engineer and which, in his judgment, could be made of equal importance from the purely educational view.

Both the instructional method of presenting most of the subjects taught at the university and the subjects themselves have been changed considerably from the curriculum ordinarily offered by technical schools.

Recognizing, as he does, the possibilities of serious errors resulting from a false point of view, and the value of establishing correct principles as a foundation for the technical education of the young engineer, the writer desires to call the attention of those engaged in instructional work to the changes made and the methods pursued in this department of the University of Wisconsin and to ask a fair and impartial discussion of the ideas introduced and the methods followed. That they are far from perfect, the writer is fully aware. As they now stand, they are the result of four years of careful consideration from the standpoint of the teacher and of twenty-four years' practical experience in active professional work.

No independent department of hydraulic engineering existed at the University of Wisconsin prior to the writer's appointment to that chair. The subjects taught were divided among various departments. Theoretical hydraulics was taught by the department of mechanics as a part of the course in theoretical mechanics; water supply, sewerage and sewerage disposal were taught by a member of the faculty who also taught structural engineering. Hydraulic machinery as taught included only a theoretical discussion of the hydraulic turbine and the laws of flow through its guide passages and buckets; hydraulic laboratory work was taught in connection with work in the steam laboratory. These subjects were differentiated and brought into the department of hydraulic and sanitary engineering.

The writer's conception of university work is that it should embrace, as far as possible, two objects:

First—The instruction of the students of the department.

Second—The extension of knowledge in department lines.

The work of instruction is designed primarily for the undergraduate, but it is intended to offer also the maximum facilities for advanced work and, as far as possible, to make the advantages of the department, and especially the facilities of the laboratory, available to practicing engineers. It is hoped to accomplish the latter through the summer school and by a proposed short course during mid-winter.

The writer believes that instructional work should include the three following essential ideas:

First—A thorough conception of the theoretical foundation of hydraulic principles, illustrated experimentally in the lecture room in order to assure a complete understanding and full appreciation of their significance. This work is to be followed and reinforced by personal experimentation by the student himself, and calculation based thereon.

Second—The application of theoretical principles to professional work. In this connection instruction should be given not only in the application of principles, but also in the method of meeting and solving engineering problems, and applying to such solutions theoretical principles not only of hydraulics but of other theoretical sciences which must be correlated and applied in successful professional work. By such means the attention of the student may be drawn to the application of his various theoretical studies and to the various necessary modifications of theory in practice.

Third—The direction of the attention of the student to the fact that university work is preparatory only: that he is learning how to study, how to investigate, where and how information can be obtained, and how to apply his information and the result of his investigation to engineer problems; that to become an engineer will require much future study and much experience and practice, and that to stand high in his professional attainments and to specialize in any branch will require continued devotion to study and investigation throughout his professional life, to which his university life is simply introductory.

Theoretical hydraulics, as taught previous to 1904 in the University of Wisconsin, and, as far as the writer is informed, in most technical institutions, consisted of a theoretical discussion of hydraulic principles, practically separate from demonstration in the laboratory or other illustrative work. The laboratory work was practically separate and was not carried on in direct connection with and as a part of the theoretical course. It was, indeed, found impossible, at the University of Wisconsin, to carry on the laboratory work parallel to and in direct connection with the work of the theoretical course. This was largely due to the fact that every laboratory is limited both in size and equipment; that the time available for laboratory work is also limited; and that it is therefore impossible for the students each to perform the experiments at the same time they are studying the text, which would illustrate the text and make it plain and bring about a full realization of the theory discussed. This theoretical work, given entirely or partially apart from any illustrative experimental or laboratory work, has been very unsatisfactory in its results. Students, as a rule, do not become interested in the subjects which they understand with difficulty, and which are illustrated only by such cuts and pictures as can be made and reproduced in the text book. They usually fail to grasp the full meaning of the theory or to appreciate its application and the course seems of little direct value, beyond a fundamental training, to many, until they enter into active practice and begin to realize from their own actual experience the meaning and bearing of the subject.

The writer realizes that no subject can be so thoroughly well taught that it will become fully the mental property of the student until he has had the opportunity of putting it into active use in his practice in many places and at many times. He then begins to fully realize the meaning and importance of a subject from his own experience.

It has, however, appeared to the writer that it would be possible to illustrate and demonstrate the ideas, conceptions, and theories of hydraulics, which it is desired to convey to the student by class-room experiments, in such a way that he could better appreciate the meaning and intent of these theories and conceptions and be more ready and able to apply them correctly to his practical work when such work comes to hand. No instructor would consider, at the present day, that physics could be well presented to the student entirely from the text book and without class-room illustrations. The fundamental ideas of physics are usually most completely demonstrated, illustrated or emphasized by experiments, which often leave a life-long impression on the students. The writer can recall the full details of many such successful and instructive experiments, in his own college days, which illustrated and emphasized principles that have remained so clearly outlined in his memory that he will never forget them.

It would seem, therefore, that the same principles should be applied to the teaching of hydraulics and, with this idea in view, a lecture room is now equipped in the hydraulic laboratory in such a manner that the fundamental ideas and principles, or, at least, the most important of them, can be demonstrated and explained to the students during the discussion of theoretical hydraulics. It is intended that the work in this line shall be carried on very much the same as in the physics lecture room. The apparatus is arranged and ready for use, or is perhaps already in operation, when the hour for class-work arrives. The theory is demonstrated by these experiments and, from the information gleaned from the experiments, problems are considered, reported, and worked out in the class while the experiments are fully in mind or while they are being demonstrated or repeated. It is believed that the results of this method of instruction cannot but be a very great improvement on the previous method used. The student will learn not only from his text book what must be expected under given conditions, but he will see the results of the theoretical deduction fully demonstrated. The theory, and the facts in the case, will be seen to accord, and a knowledge of their relations will become his, for he will receive not only a mental but also an optical demonstration of them. He will not be obliged to take the statement of the instructor or author of the text book for the facts, because he will see them for himself and will become an authority for the fact. His interest will become aroused, his attention will be attracted, and that which was before a dry and uninteresting subject will become attractive and of real interest. The result, it is believed, is of importance not only in the teaching of the fundamental principles of hydraulics but also in the laboratory work which will follow. Students become better acquainted with the subjects and are better prepared to undertake the determination of some of the more important facts which it is desired to emphasize by means of laboratory work.

The writer has described in another article the new hydraulic laboratory of the University of Wisconsin and will here outline only a few of the illustrative experiments performed before the various classes in the department.

Fig. 1 shows a jet experiment by which some of the fundamental principles of hydraulics are illustrated. At the right is a tank about three feet square which is kept full of water to the desired gauge height by a supply pipe entering the tank at the bottom. Three standard orifices are placed in one side of the tank and discharged into the receiving basin upon which the tank rests. A blackboard ruled in feet and tenths is placed with the zero line of its abscissas on a line with the plane of the orifice and closely behind the jets passing from them. The paths of these jets are clearly outlined against the cross section of the blackboard.

The following illustrates two calculations based upon the experiment:

To prove Torricelli's theorem by this experiment, *i. e.*, that

$$v = \sqrt{2gh}.$$

$$h = 4.52 - 2.00 = 2.52.$$

$$v = 8.02 \sqrt{h} = 8.02 \times 1.587 = 12.728 \text{ ft. per sec}$$

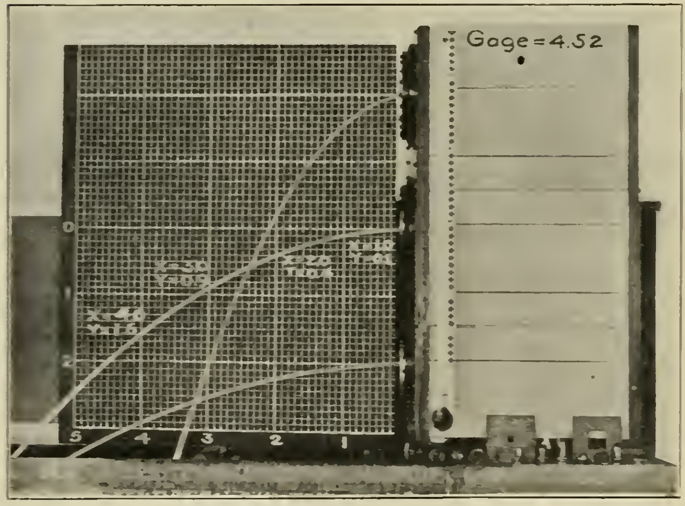


FIG. 1.

Time to pass through space of 4 feet at rate of 12.728 ft. per second

$$4/12.728 = 0.3142 \text{ sec.}$$

Distance a body will fall in 0.314 sec. =

$$s = \tfrac{1}{2}gt^2 = \tfrac{1}{2} \times 32.16 \times (0.3142)^2 = 1.587 \text{ ft.}$$

Check on blackboard

$$s = 1.6 \text{ feet.}$$

To show that the path of the jet follows a parabola with equation

$$x^2 = 2py,$$
$$p = 5.$$

Let $y = 0.1$, then $x^2 = 2 \times 5 \times 0.1 – 1$ and $x = 1$ checked on blackboard.

Let $y = 0.5$, then $x^2 = 2 \times 5 \times 0.4$ and $x = 2$ checked on blackboard.

Let $y = 0.9$ then $2 \times 5 \times 0.9 = 9$ and $x = 3$ checked on blackboard.

Let $y = 1.6$ then $x^2 = 2 \times 5 \times 1.6$ and $x = 4$ checked on blackboard.

To show the conversion of energy from potential to kinetic and its reconversion to a potential form, and the losses commonly entailed in such transformation, the experiment illustrated in Fig. 2 is introduced.

In this experiment the jet is discharged through a nozzle from the right hand tank under a head of four feet and has a velocity of about 95 per cent. of that due to the head, which is demonstrated by a pitot tube. The actual loss in head and consequently in energy from the transformation is about 10 per cent. The kinetic energy of the free jet after passing unconfined through a space of about six inches is reconverted into potential form by entering a gradually expanding tube attached to the tank on the left where, on account of the condition, only about 75 per cent. of the velocity energy of the jet is recovered and a loss in head of about 1.61 feet, or about 44.4 per cent. results. The net result of the experiment is a total loss in the entire conversion and reconversion of 50 per cent of the original energy.

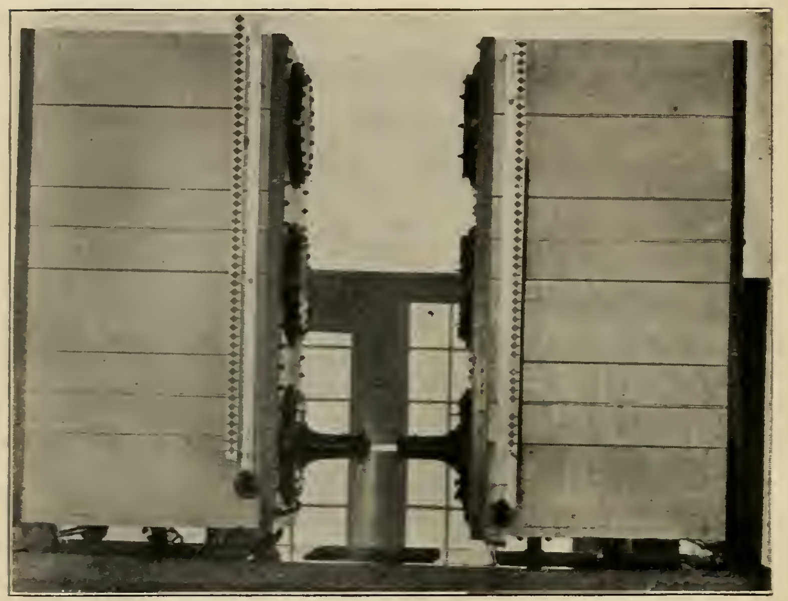


FIG. 2.

To illustrate in the lecture room the principles of the reaction turbine, a simple form of this machine, shown in Fig. 3. has been constructed. This is the form known as Barker's mill and consists of a body of 10-inch wrought-iron pipe provided with a bottom and shaft with six nozzles attached tangentially near the base. A brake pulley, *B*, is attached near the upper end of the shaft, and a string break passes around the pulley, being attached to a weight, *W*, (with scale *S* indicating its amount) at one end, and to a friction weight, *A*, at the other. Various principles of the reaction turbine are illustrated and demonstrated by the operation of this wheel. For example: to show that, with a given head, a wheel must operate practically at one certain speed in order to develop the maximum power from the wheel, water

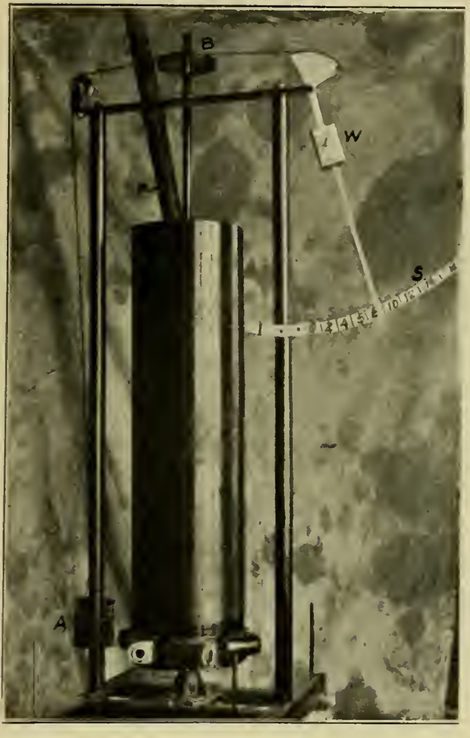


FIG. 3.

is admitted through the pipe, *P*, the brake cord is loosened, and the wheel begins to revolve (see Fig. 4). When the head has become constant and the revolutions uniform, the revolutions per minute are determined by revolution counter and the runaway speed, or the speed at which the machine will operate without other than its own friction load, is thus shown. A load is gradually applied to the wheel by adding weight in the scale pan, *A*, and the effect is measured on the scale, *S*.

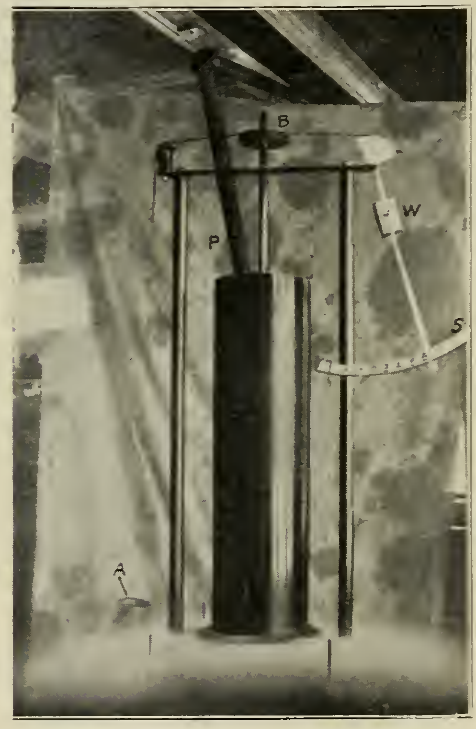


FIG. 4.

The net added friction load is the difference between the scale reading, *S*, and the friction weight, *A*. Readings are taken with various loads and speeds. The student observes the data, calculates and plots the results in order to obtain a graphical representation of the law and to impress the principle on his mind.

The same facts are also shown by experiments on a tangential or impulse wheel (see Fig. 5). The following are the results of two experiments on these wheels made before a class of more than one hundred students. Each student calculated the results and plotted curves showing the relation found between power and speed (see Fig. 6) thus emphasizing and making clear to the student the fact that in all cases in order to obtain the maximum power of a water wheel, the peripheral velocity of the wheel must bear a certain definite and fixed relation to the velocity due to the head.

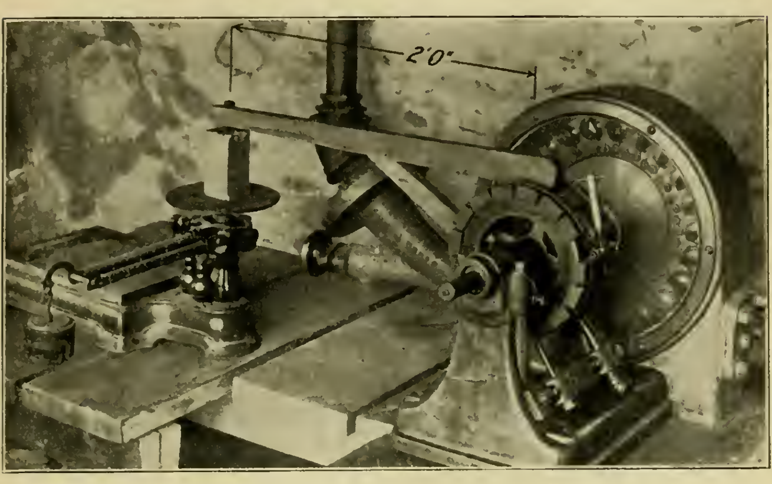
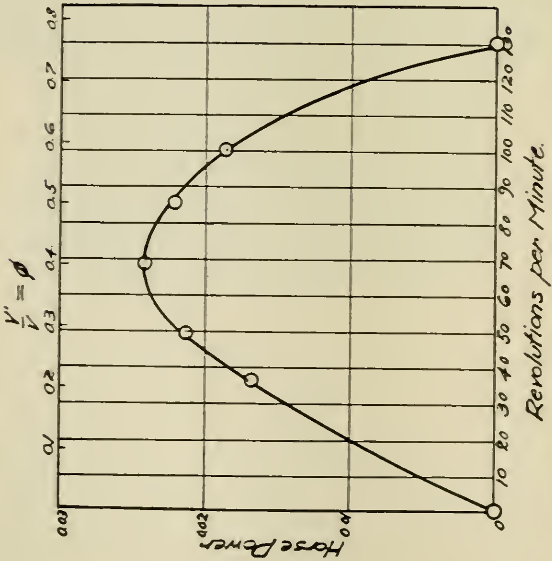
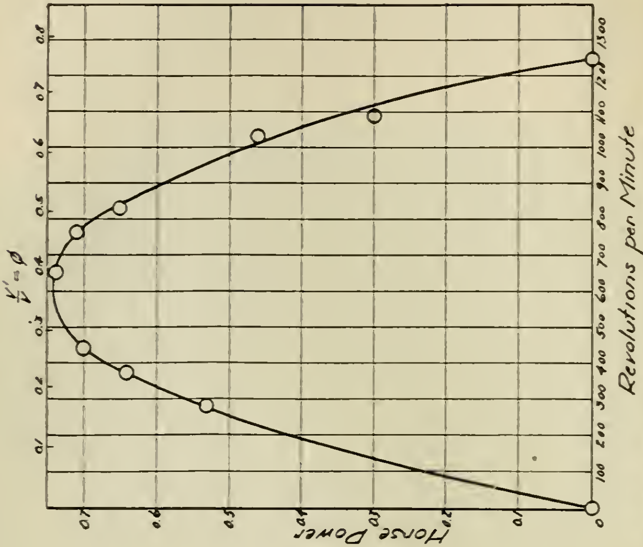


FIG. 5.

The theoretical work in hydraulics at the University of Wisconsin is now confined to the first ten weeks of the semester during which period the various lecture room experiments are performed to illustrate and demonstrate the theoretical study. The last five





POWER SPEED CURVE OF A 1.4' REACTION TURBINE. POWER SPEED CURVE OF A 1.0' DOBLE TANGENTIAL WHEEL

FIG. 6.

EXPERIMENTS WITH REACTION WATER WHEELS.

Diameter of wheel .... 1.4 ft.
Head of water .... 2.5 ft.
Diameter of brake pulley .... 0.5 ft.

Weight Scale S.	Friction Weight A.	Net Weight on Brake.	Rev. Per Min.	Developed Power.
0.	0.	0.	130	0.
4.6	0.75	3.85	100	0.0185
6.8	1.4	5.4	85	0.0122
9.6	2.2	7.4	68	0.0242
12.0	2.9	9.1	49	0.0214
13.2	3.5	9.7	36	0.0168
14.2	4.1	10.1	0	0.

EXPERIMENTS WITH DOUBLE TANGENTIAL WHEEL.

Diameter of wheel .... 1.0 ft.
Head of water .... 115 ft. or 50 lbs.
Lever arm .... 2 ft.

Weight Scale S.	Friction Weight A.	Net Weight on Brake.	Rev. Per Min.	Developed Power.
0.	0.9	0.	1,250	0.
1.6	0.9	0.7	1,090	0.294
2.1	0.9	1.2	1,030	0.475
2.9	0.9	2.0	830	0.638
3.3	0.9	2.4	760	0.710
3.9	0.9	3.0	650	0.748
5.1	0.9	4.2	440	0.700
5.4	0.9	4.5	370	0.640
5.9	0.9	5.0	280	0.537
7.6	0.9	6.7	0	0.

weeks of the semester are given up to laboratory work, the time spent being so concentrated that the student has a longer time at each period to devote to his experimental work.

In laboratory work the student is first assigned a reference to some similar experimental work, of which he makes an abstract. He then investigates the apparatus to be used and reports on the methods he proposes to follow; he then performs the experiments assigned, taking care to secure a high degree of accuracy. He finally calculates, under the direction of the instructor, the coefficient or results determined by the experiments.

There is thus secured: (1) Experimental demonstration before the student of the theory under discussion and a clear comprehension of the principles involved; (2) the personal investigation by the student of the extent of information available on any subject to be investigated. A study of the apparatus and methods used for further investigation. The personal experimentation by the student himself illustrative of the principles he has already studied in his theoretical course, and his calculation of the results of such experiments and the determination of the coefficients by which the theoretical results are modified.

As far as we are able to judge, the results have been much more satisfactory than the earlier methods which we were obliged to pursue during 1904–5 and 1905–6, before the laboratory and lecture room apparatus was available. Our judgment is based on the expression of the students themselves, and the results now attained in advanced work, the choice of elective advanced courses by engineer students, and the interest shown by the election of hydraulic research work for thesis subjects.

There has been introduced into the curriculum of the hydraulic engineering department the subject of hydrology, not hitherto taught in the University of Wisconsin, or, as far as the writer knows, at any other institution. From the writer's practical experience in hydraulic work he believes that the most prolific source of failure in hydraulic installation, hydraulic problems, or schemes in which hydraulic problems are involved, is the lack of fundamental knowledge of many of the principles that are included under the title of hydrology.

The writer has stated in another place that "Hydrology, in its broadest sense, treats of the properties, law and phenomena of water; of its physical, chemical, and physiological relations, of its distribution and occurrence over the earth's surface and within the geological strata, and of its sanitary, agricultural and commercial relations." In presenting this subject to engineering students such relations as bear more specifically on the work of the engineer are discussed and considered. It is the writer's belief that a study of this subject should precede all advanced work in hydraulic engineering. At present, at the University of Wisconsin, the subject is required of the students in civil engineering only and prior to their consideration of the subjects of water supply, drainage, irrigation, and of sewerage and sewerage disposal. The students in mechanical and electrical engineering who are required to take up the course in water power are not required to take hydrology as a prerequisite to the water power study. In consequence of this fact, those elements of this subject which bear more specifically on the subject of water power are discussed in the water power class. It is the writer's belief, however, that the subject of hydrology should be a required subject for all engineering students just as much as the subject of theoretical hydraulics, and that it is more essential than the advanced professional work.

The other subjects taught in the department are public water supply; drainage, sewerage and irrigation (considered as a single subject): water power; hydraulic machinery; and rivers and canals. In all of these subjects an attempt is made not only to develop the theory on which these subjects are based, but to show the application of this theory by illustration from actual practice. An attempt is made, in this way, both to make the subjects interesting to the student and to bring home to him the fact that the principles are real, living principles which every engineer who would be successful must understand and be able to apply. He is made to realize as fully as possible that the theories, problems, and laws which are brought to his attention are not simply mathematical and scientific mental gymnastics for his educational benefit but are also of direct and living interest and that a full knowledge of the same is vital to his professional success. As far as possible, the structures and machines which are considered are illustrated by models, and when models are not available, drawings, photographs and lantern slides are used. The student is called upon to work out practical problems of such a nature that while their utility is fully recognized by him they, yet involve and emphasize the theoretical principles which must constitute the educational foundation of every successful engineer. The student is taught that a knowledge of the methods of theoretical analysis is essential for his successful consideration of a subject, but that the knowledge of their application and the development of his judgment are of equal importance. He is taught that both theoretical knowledge and practical technical experience must go hand in hand and that either without the other is imperfect; and an attempt is made to have him fully realize the advantage of his educational opportunities, at the same time to fully understand that without the actual experience that is developed only by practice his theoretical education is unsatisfactory and incomplete and can be applied only with almost certainty of serious error.

Besides the subject of theoretical hydraulics, perhaps the greatest departure that has been made from past practice among technical schools is in the instruction on the subject of hydraulic machinery. All text books on hydraulic machinery, so far as the writer is aware, are written principally from the standpoint of the designer, of the man who is expected to undertake the construction of this machinery. That is to say: the theory of the machine and the theoretical effect of modification in form and design are discussed, and the practical results of its actual use are not considered. Of the students who pass through our educational institutions a very small percentage give their time and attention to the manufacture of hydraulic machinery. Almost all of them, however, will use machinery of this kind to a greater or less extent. Almost all of them, therefore, are interested in the selection of machinery, in its installation, its operation and maintenance, and it is from this standpoint that an attempt is made to consider this subject at the University of Wisconsin. The engineer who is called upon to select and install this class of machinery for his client or employer is necessarily and particularly interested in the details of construction so far as they will affect the efficiency and operation of the machine. He may feel an interest in the details of manufacture but a knowledge of the minutiæ is seldom essential to his purpose. His interest is centered in the selection of the machinery which forms a part of the plant that he is called upon to design, and he regards the machines in question as only a part of a perfect whole which it is his duty to create. To him a machine is a unit which, with other units, must be selected and installed in order to form a complete and satisfactory plant. His interest in the details of the machine lies particularly in their effect on its operation, maintenance and efficiency. He is not necessarily an expert on any one class of machinery but he must not only understand the single class of machinery in which the expert is interested, but he must also be familiar with a great variety of machinery to which other experts may be giving their entire attention and concerning the minute details of which it is impossible for him to thoroughly inform himself. The mental capacity of a man is not sufficient to permit him to know in detail all things; hence the necessity of an expert. Hence, also, the necessity of the man whose general knowledge is in sufficient detail to be able to compare the values of various classes of machinery and to select those classes which are of the proper type for the particular purposes of the installation which he may have in charge. The point of view of the machine designer and of the engineer of the installation have much in common, and the installing engineer is, of course, all the better fitted for his work if he understands thoroughly all the details of construction of any machine which he is called upon to select and utilize, provided at the same time his knowledge is broad enough to give him a correct conception of the relative importance of other machine units which should be considered in selecting the parts of the complete installation. He needs specific information concerning the general features of all machines with which he must be necessarily acquainted in order to intelligently and satisfactory accomplish his purpose. It is this conception of hydraulic machinery which the writer is endeavoring to embody in the course in hydraulic machinery.

It must not be understood that an attempt is being made in this case to introduce a large amount of disconnected information which, while important to the practicing engineer, nevertheless does not constitute the foundation for a proper technical education, for such is not the case. In this course an attempt is made to create the necessary theoretical basis which will allow of correct deduction in the subject considered, to furnish the fundamental basis on which the principle of the selection of machinery must depend, and to develop those principles in regard to machine construction which is not only important but essential for every practicing engineer—who is obliged to select, install, operate or maintain various classes of machinery—to know in order that his work may be done to advantage. In all these subjects an attempt is also made to assure a knowledge of the literature of the subject so as to make it fully available for future study and research, to impress the necessity of careful and detailed study of each particular problem by itself and to induce a recognition of the theoretical principles which must underlie the subject and which are necessary for its proper consideration and for its successful treatment.

An essential feature of the writer's conception of his department work is the extension of knowledge along hydraulic lines. Considerable attention therefore has been and will be given in the laboratory to advanced and research work.

Experiments of considerable importance have been completed on the flow through submerged orifices four feet square, the results of which are set forth in Bulletin No. 216 just issued. The volume of water available in this main channel of the laboratory is about 30,000 gallons per minute, or 67 cubic feet per second and offers a considerable opportunity for research work with apertures, weirs, racks, etc., of considerable size.

The experiments on the flow of water through submerged orifices and various forms of short conduits will be extended, and it is also intended to investigate the effect of racks and other obstructions on the flow of water through this large channel.

It is intended to direct advanced and thesis work in lines where further information is desirable, and to so direct and check such work by expert advice and supervision that the results obtained will be reliable and of general value. Results of interest will be further investigated, checked and extended, and as fast as the conditions seem to warrant will be published.

The writer believes that there is at present available in the hydraulic laboratories of the various universities and technical schools much information, frequently the results of undergraduate work, which, if edited and published, would be of great value to practicing engineers. It is true that much of this work is subject to considerable error, and that it cannot be accepted without due consideration. Frequently, however, the experimental errors are much less than those which would be met in the actual application in practice and the data are therefore valuable. The writer believes that the presentation of such available information is a duty which the school owes to the profession—a duty that has not been as yet either properly appreciated or performed.

It is proposed at Wisconsin to carry out these ideas as fully as conditions will warrant, and to offer to the profession such information as may be available both from students' work and the more exact work of instructors and expert experimenters.

The students' work will be guided and checked as far as practicable and will be discussed as to accuracy and application by those capable of a clear conception of the relative value and importance.

Special lines of importance will be investigated by expert experimenters. One special line of experimentation, which has been under way for about two years, is in relation to centrifugal pumps. For this purpose a special pump has been designed which is sufficiently flexible to admit of a wide range of change in detail. Six forms of cases have been designed, some of which can also be varied by the addition of various forms of fixed turbine blades. Twenty-four forms of closed impellers, in which the number and shape of the impeller blades vary, have been constructed. All of these are to be increased in number and varied in design as the results of the experimental work may warrant. This experimental pump is operated by a fifty horse power variable speed electric motor, and can be run at a wide range of speeds. The motor current is determined by the most accurate forms of laboratory testing instruments, and the motor losses are determined with great care, so that the actual power reaching the pump is known with a considerable degree of accuracy. Provisions have been made for a careful study of pressures and velocities in the cases and passages of the pump, and the discharge is obtained over a carefully calibrated weir.

The object of this series of experiments is the establishment of the laws of flow in machinery of this type and the determination of the features which will result in high efficiencies and permit of the attainment of high heads. A special vertical type of centrifugal pump, intended primarily for deep well work, designed by Mr. John W. Alvord, of Chicago, has been presented to the laboratory by Mr. H. H. Porter, president of the Chicago Clearing and Transfer Company. This pump has been tested in this series of experiments which, it is expected, will also be extended to pumps of various standard designs and manufacturers. The detailed results of the experiments with the Alvord pump are published in Bulletin No. 173 of the University of Wisconsin.

An experimental study of the fundamental principles of the hydraulic ram has been made recently by Mr. Harza and published in Bulletin No. 205. Various other bulletins, some six or more in number, are now under preparation.

While the subject of hydraulics is one that has received much attention from the earliest times, yet there are many problems that have not been sufficiently investigated and principles that have not been thoroughly established.

The research work of the hydraulic laboratory, therefore, is believed to be an important part of the work of the department.

The research work, described in Bulletins Nos. 173 and 205, has been made by and under the direction of Mr. C. B. Stewart, who has three other bulletins in preparation. The theoretical hydraulics and instructional laboratory work is in the immediate charge of Professor G. J. Davis, Jr., and Mr. A. H. Ayres. The present course in theoretical hydraulics and laboratory work is largely due to Professor Davis. The advanced laboratory and thesis work is supervised by Professor Davis, Mr. Ayres and the writer.

DISCUSSION.

DEAN MARSTON: I would call attention to some ideas put forth in this paper in reference to teaching hydraulics. I recently had the pleasure of examining the hydraulic laboratory of the University of Wisconsin, and it seems to me that the methods of demonstrating the work by actual experiments in the lecture room before the classes save much time that has heretofore been wasted in accustoming students to carry out experiments in the laboratory. Professor Mead's work is the result of twenty-four years' active hydraulic engineering and four years' work at the university.

I think that most of the engineering graduates of our schools retain interest in the educational work of their alma maters. We get interesting letters from our engineering alumni in which they express very decided opinions as to different features of engineering education. It is an advantage to us to have such men take an active part in planning the work of our engineering schools and many mistakes in engineering education might be avoided by active cooperation between engineers in practice and those in educational work.

PROFESSOR HIBBARD: I want to speak of the cultivation of self-dependence. I believe emphatically in that. While there are several excellent results to be obtained from laboratory practice, and the desire of our expert laboratory instructors to give the largest range of experiments, to teach the largest number of principles—I believe that there is always grave danger that each experiment will be too thoroughly digested by the instructor for the student's good. I have talked with a number of engineers, who have told me of their engineering colleges, and have found many of them emphasizing the value to them of certain experiments in which the responsibility was placed upon them; and in which the instructor did not tell them very much of how to do things. Of course that can easily be carried to the extreme; but, I think the danger is the other way, and that the instructor is anxious to have things too thoroughly explained so that the students themselves do not have to do enough thinking and thus can accomplish more in the eyes of the instructor.

Every year I have the opportunity given me of testing a locomotive on a railroad leading out of our city. Last month I took the students down to the round house to prepare the engine for the test. I did as little as I possibly could myself. I made the students responsible. It took them a little longer to rig up, of course. I suppose if I had directed their efforts they would have rigged it up in two and a half days, whereas it took them about four days. But I believe, and the seniors said that they believed, that they got immeasurably more out of it than if I had told them how everything was to be done. They made mistakes, and I had to correct them. They were told to put on certain pieces of apparatus but I would not tell them how best to do it. I would say, exercise your own ingenuity, getting on the best way you can, and after you have done the best you can I will tell you if I think it is not as good as it might be. There were a number of experiences just like that. When I corrected them, I would not say, "You ought to do it such a way," but I would say, "That is not the right way for thus and thus reasons. Now try and think out some better way to do it." Some of them would say, "I wish you would tell me how to do it." I would reply, "I think it is your job to find out how to do it."

DEAN KENT: I agree with all that has been said on laboratory practice, but I want to suggest another thing. In addition to making the boys do their own thinking, I think it is proper to have a jack of all trades or "universal tinker" who can turn his hands to doing all the things of an incidental nature that take up much of the boys' time. The boys should not be made to do every common mechanic's work in getting things ready; their time is too valuable to do that kind of work instead of having men do the work for them. In practical engineering an engineer does not do as much with his hands as he does with his head.

ELECTRICAL LABORATORY EQUIPMENT AND EFFICIENCY.

BY S. SUMNER EDMANDS,

Head of Department of Applied Electricity, Pratt Institute.

The unusually difficult conditions that have had to be met in the electrical laboratory instruction at Pratt Institute have forced upon us an extended study of certain features of electrical laboratory equipment that have hitherto received but scanty attention in the great majority of electrical laboratories. It is doubtful whether at any other educational institution in this country the electrical laboratory has been obliged to operate under such a severe combination of conditions as to size and number of sections in proportion to the size of laboratory and number of instructors, and high cost of floor space and limited funds for equipment in proportion to the needs—conditions requiring unusual economy in the equipment and instruction. In addition the shortness of our course demands that the students' time be used with the greatest possible degree of effectiveness.

We have been experimenting with various features of the problem for the last five or six years while the work has been growing, and have been continually discarding or modifying our conclusions as suggested by further experience until we feel confident that we have now arrived at a reasonably satisfactory and permanent solution—a solution radically different from our preconceived notions, and one that has been the outcome of the conditions referred to in much the same way that the modern tall office building has been made necessary by values of office rental and high cost of land, or that rapid transit has been forced by congestion of population.

Inasmuch as other institutions are beginning to experience a similar pressure demanding greater effectiveness in the use of their electrical laboratories, and will soon have to face many of the problems that we have considered, it is thought that a description of our method of electrical laboratory equipment will be of interest to many members of this Society.

The dynamo laboratory equipment at Pratt Institute is arranged in accordance with what may be termed the *unit system,* a *unit* of equipment consisting commonly of a direct connected motor and generator, or perhaps, of a rotary converter, or of a motor and an absorption dynamometer, together with a small switch panel and a shelf for instruments, all of which are mounted together upon a skeleton steel frame. A typical unit, complete as above described, is shown in Fig. 1, consisting in this instance of a five horsepower variable speed, three phase induction motor, and a three kilowatt compound direct current generator. A lampbank or other device for absorbing electrical energy is included in the equipment constituting the *unit,* but is commonly mounted upon a nearby wall for convenience and economy of space.

Unless there be special reasons for having one or more duplicate sets of dynamo machines, other equipment *units* are similar to the one shown in Fig. 1 only in respect to the steel frame and the general details. The dynamo machines are different and are so chosen that the collection as a whole will properly represent the various types of commercial electrical machines, and will afford facilities for experiments over the whole range of electrical machinery. For example, the dynamo equipment of some of the other units comprises a direct current motor and an alternating generator,—a direct current motor and a direct current generator,—and an induction motor and a Prony brake. Various other combinations are feasible and desirable and will naturally suggest themselves.

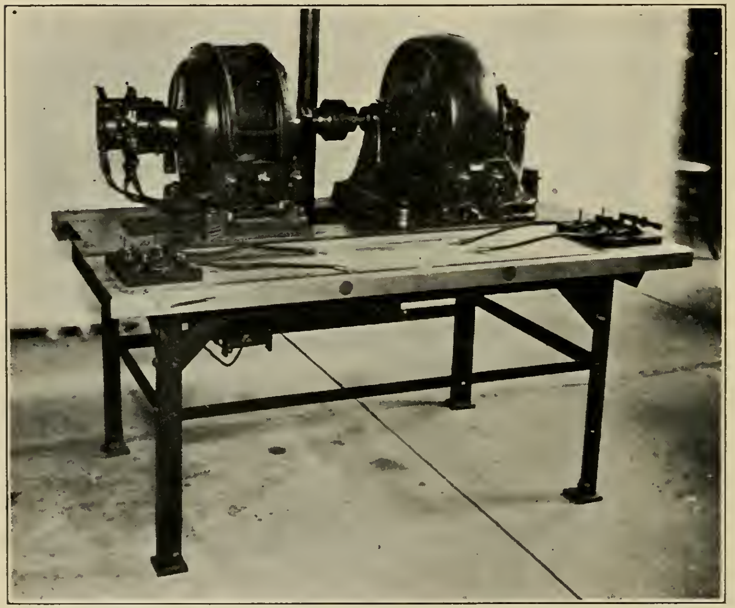


FIG. 1. Motor Generator Set Without Auxiliary Equipment.

It should be especially noted that the equipment *unit* includes no instruments, rheostats, or other auxiliary equipment, which would, of course, be necessary for the performance of experiments, nor are the dynamo machines in any way connected or wired, nor are there any indications of what connections, instruments, switches, rheostats, etc., should be employed for any use whatsoever to which the machines may be put. This auxiliary equipment is brought to the *unit* by the students and arranged and connected by them to meet the requirements of the particular experiment they are performing. The same *unit* shown in Fig. 1 is again seen in Fig. 2, with portable

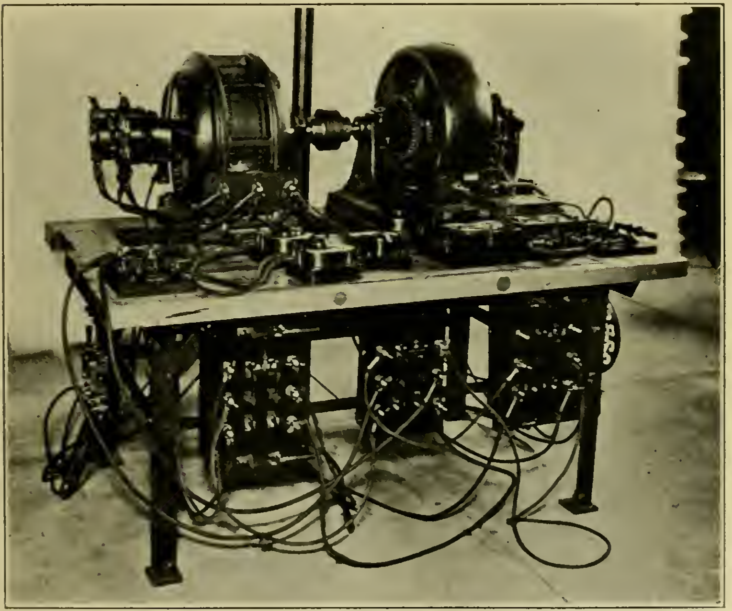


FIG. 2. Motor Generator Set With Auxiliary Equipment.

auxiliary equipment assembled and connected ready for an experiment. Fig. 3 gives a rear view of the same. It is evident that the whole arrangement is

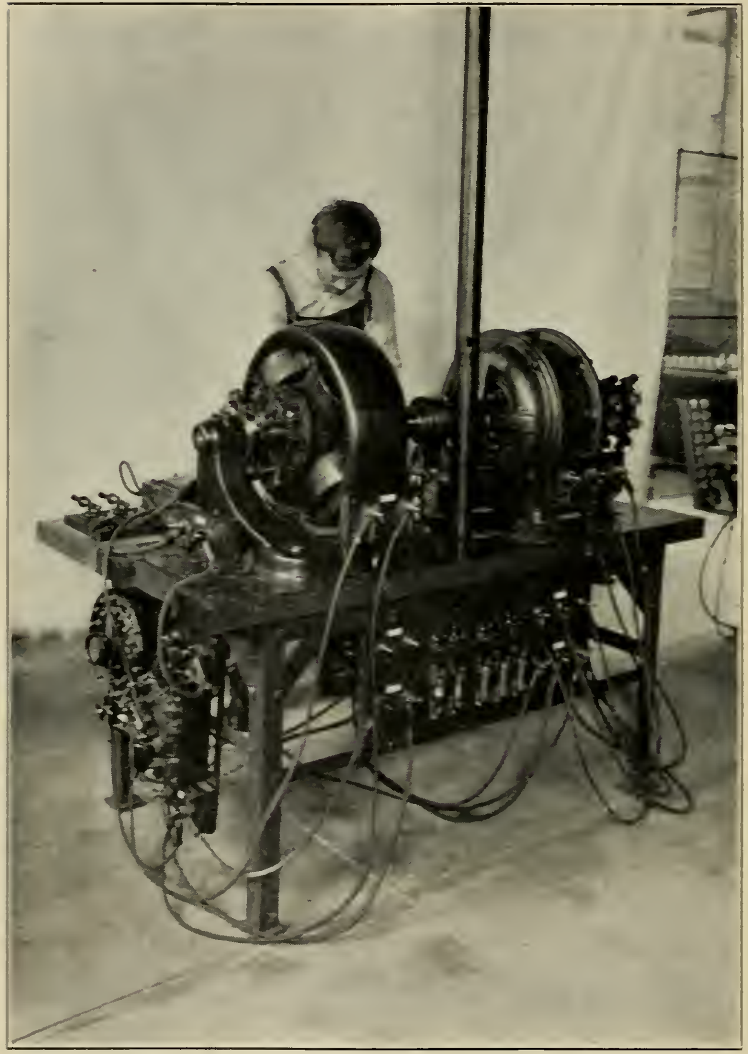


Fig. 3. A Unit and Auxiliary Equipment—Rear View.

very compact, and also that it embodies a maximum of convenience. The illustrations show strikingly how the *unit*, when stripped, offers no suggestion to the student as to method of procedure in carrying out an experiment, and yet at the same time affords means by which the student can with little expenditure of time conveniently dispose the necessary auxiliary apparatus, and proceed with the experiment, provided he knows what to do. There is no time wasted in the overcoming of minor mechanical difficulties, which oftentimes may consume more time than the experiment itself. It is, of course, evident, also, that this arrangement is perfectly flexible and equally well adapted to the performance of all of the experiments possible with the dynamo machines belonging to the *unit*.

A few further details regarding certain features of the *unit* plan of equipment will be of special interest to those who may have similar problems to consider.

A uniform size of steel frame for the *unit* is made possible by the adoption of a standard capacity for the dynamo machines. A capacity of five horsepower or three kilowatts has been selected for the Pratt Institute laboratory. Also standard voltage of 110 volts direct current and 110 volts three-phase have been adopted for the greater part of the equipment. Adherence to these standards greatly simplifies the arrangement of the units in the laboratory, and the supplying of electrical power for the experimental work, and renders the portable rheostats, instruments, switches, etc., interchangeable to an extent that greatly increases the flexibility of the equipment. Upon the small panel at the rear of the steel frame are mounted proper service switches connected to the electric mains supplying power for operating the machines,

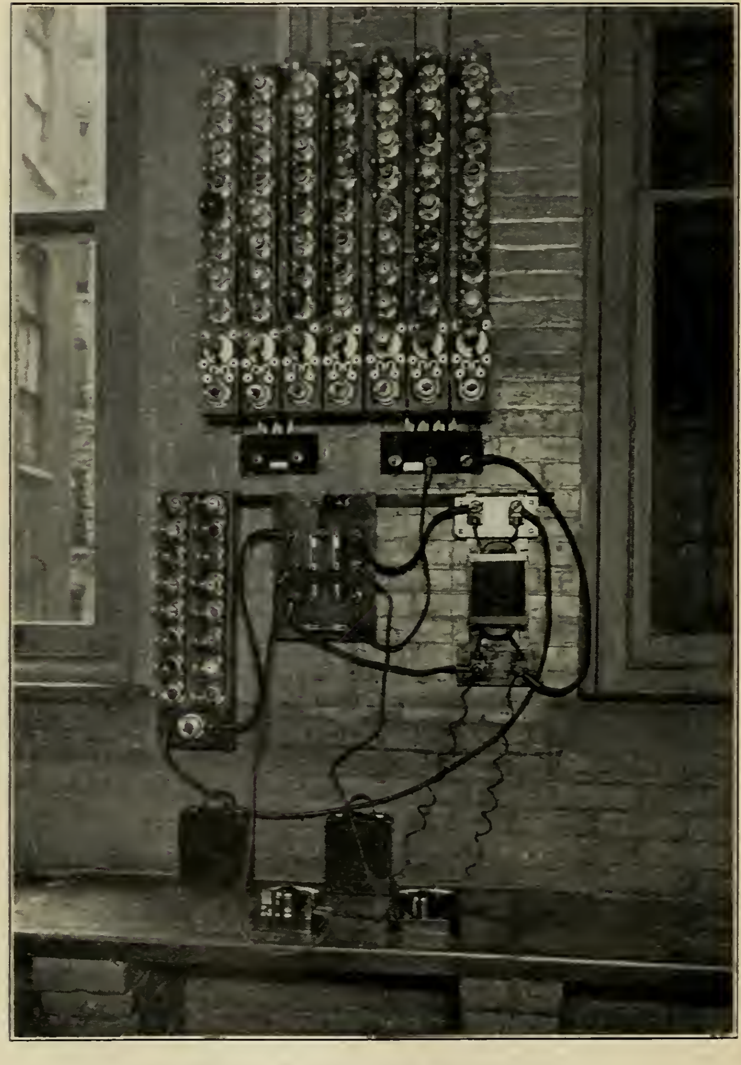


Fig. 4. A Bench Section in Service.

and on this panel terminate conductors leading to an adjustable lamp bank conveniently located on the

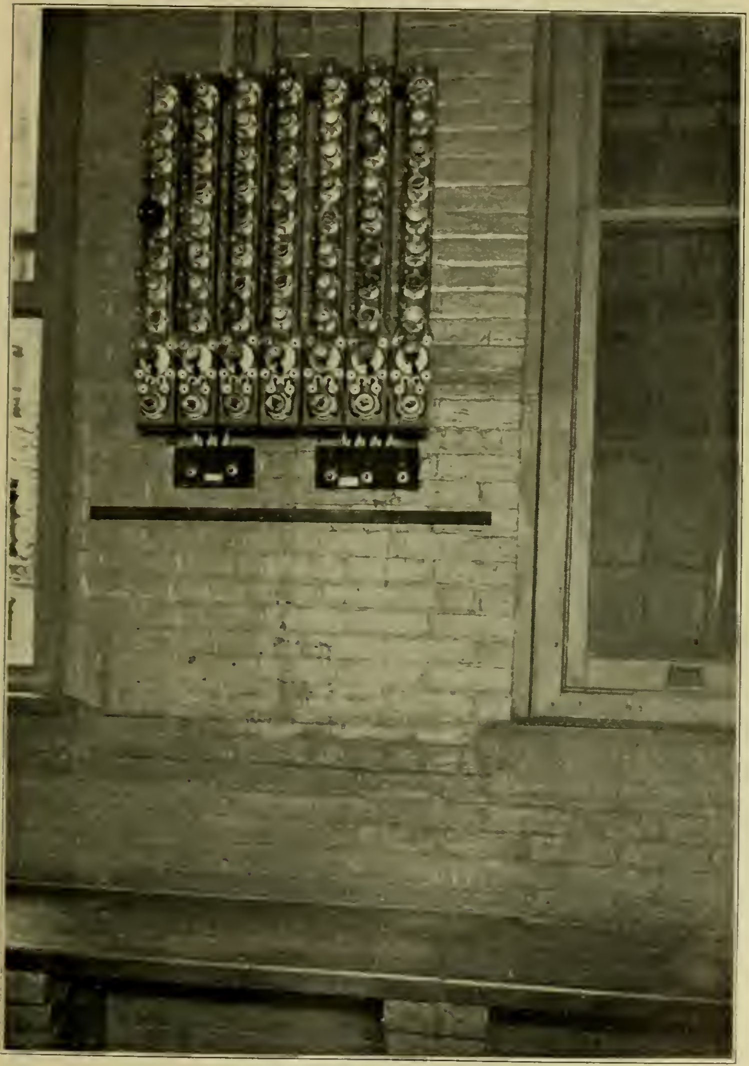


FIG. 5. A Bench Section in Dynamo Laboratory.

wall and of proper capacity for loading the generator. If lines to other parts of the laboratory are required they also terminate on this panel. The terminals of all electrical circuits, whether on permanently installed or on portable apparatus, are of uniform size and design, and a single style of connecting cable suffices for all connections between the various pieces of apparatus. Each field rheostat and each starting rheostat is mounted upon a light wrought iron frame provided with hooks or "hangers" so that it may be

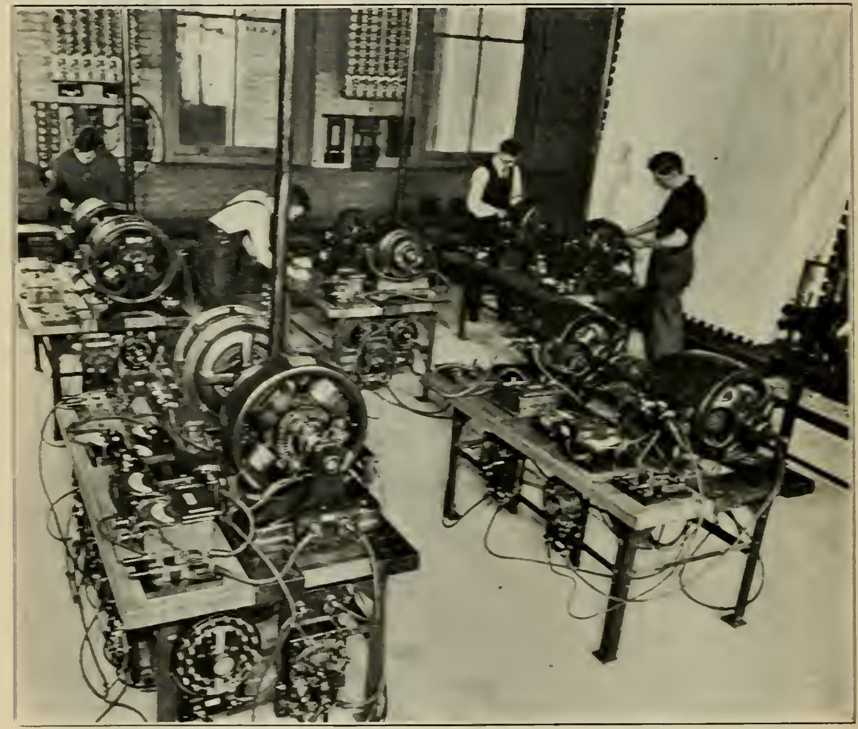


FIG. 6. The Motor and Generator Equipment.

hung on the steel frame of the *unit,* as shown in Fig. 2 and Fig. 3. The student, in performing an experiment, proceeds to the particular *unit* to which he has been assigned and finds it in the condition shown in Fig. 1.

He must determine for himself what auxiliary apparatus is necessary, and what connections should be made; and here he has only his own knowledge and originality to guide him. Having done this, he obtains the necessary instruments, rheostats, switches,

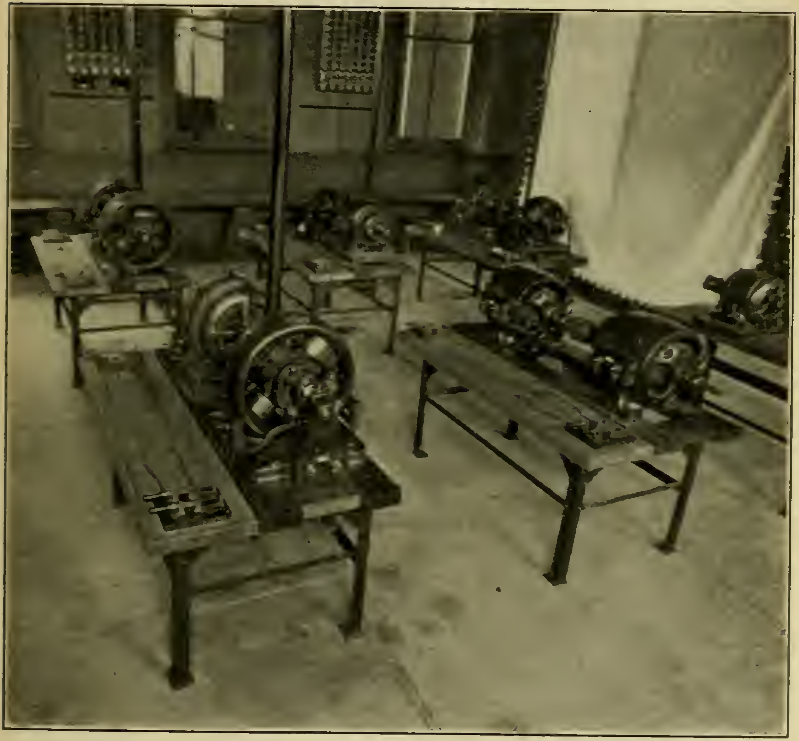


Fig. 7. A Section of Dynamo Laboratory.

cables, etc., from the stock room, or racks where they are kept, assembles this portable apparatus on the frame of the *unit*, and makes whatever connections are required, as illustrated in Fig. 2 and Fig. 3.

On the completion of his experiment, the student returns the auxiliary equipment to its proper place, restoring the *unit* to the condition shown in Fig. 1, and leaving it ready for use in the performance of any other experiments within the possibilities of the dynamo machines there installed.

The general plan of equipment that has just been described in connection with the dynamo machinery has been applied also in what are sometimes called "bench" experiments, comprising experiments with transformers, various instruments, lamps, small motors, etc., and Fig. 4 shows a bench with apparatus assembled and connected for a transformer test. The bench is normally clear and free of apparatus as shown in Fig. 5, all apparatus of the kinds mentioned being portable and arranged to hang from a rail on the wall.

A general idea of the appearance of the Pratt Institute dynamo laboratory when in use is shown in Fig. 6, only a few students being included in order that the details of the equipment may be more evident in the photograph. The *units* accommodate from two to four students depending upon the nature of the experiment. It has been found that with this arrangement one instructor can easily direct a section containing twenty-four students, a much larger number of students than can be handled satisfactorily by a single instructor in the majority of electrical laboratories. A floor space of 21 × 30 feet is ample for the installation of nine *units,* together with a bench against one wall, as shown in Fig. 6. The normal apearance of the laboratory when not in use is shown in Fig. 7.

Experience at Pratt Institute with this method of equipment has shown that the following direct advantages have been secured.

1. A very great saving of the student's time.

2. Greater effectiveness of the laboratory instruction, in that the student can concentrate his attention upon the normal difficulties and problems of the experiment, due to the elimination of the annoyance arising from inadequate or incomplete mechanical facilities.

3. An increase in the instructor's effectiveness along the normal lines of instruction, inasmuch as his attention is no longer required for the supplying of means for the overcoming of minor difficulties that in themselves possess no educational value.

4. The elimination of much confusion and interference between experiments due to the activities of the students assigned to a particular *unit* being confined to the immediate vicinity of their self-contained *unit.*

5. Orderliness and readiness for service becomes the normal state of the laboratory, greatly facilitating the handling of consecutively scheduled classes.

6. An increase in the number of students that can be properly supervised by one instructor.

7. An increase in the amount of apparatus that can be installed in a given amount of floor space.

8. An increase in the number of students that may work satisfactorily on a given floor space.

Another advantage of the *unit* plan of equipment, when properly carried out, is that alterations and extensions of the laboratories to accommodate growth or changed conditions may be readily effected with but slight sacrifice of permanent investment, since all parts of the equipment are practically portable.

Criticism may be made that we are in danger of giving the students too much help and too many conveniences for the performance of their experiments, and thereby depriving them of valuable opportunities for the exercise of their own originality and resourcefulness. This possibility is avoided by requiring each student to devote a definite amount of time to assisting in the design, construction and installation of the various parts of the equipment; and in this connection it should be stated that the equipment of the Pratt Institute electrical laboratory is, with the exception of certain standard apparatus including machines, instruments, rheostats, etc., constructed by the students, thereby affording not only valuable practical experience for the students, but also greatly decreasing the outlay necessary for the purchase of the equipment. This design and construction work is of great advantage to the students and is conducted under the systematic supervision of an instructor. Thus the student contributes to the provision of the facilities that enable him at another time to concentrate his attention upon the technical problems of the experiments with the net result that all of the time allotted to laboratory work is effectively employed to secure the greatest possible benefit to the student.

CEMENT LABORATORY PRACTICE.

BY IRA O. BAKER.

Professor of Civil Engineering, University of Illinois.

In the fifteen volumes of the Proceedings of this society there seems to be nothing relating to the equipment of a cement laboratory or to instruction in testing cement. That this hiatus may no longer exist, the author proposes to describe the cement laboratory of the University of Illinois and the practice therein.

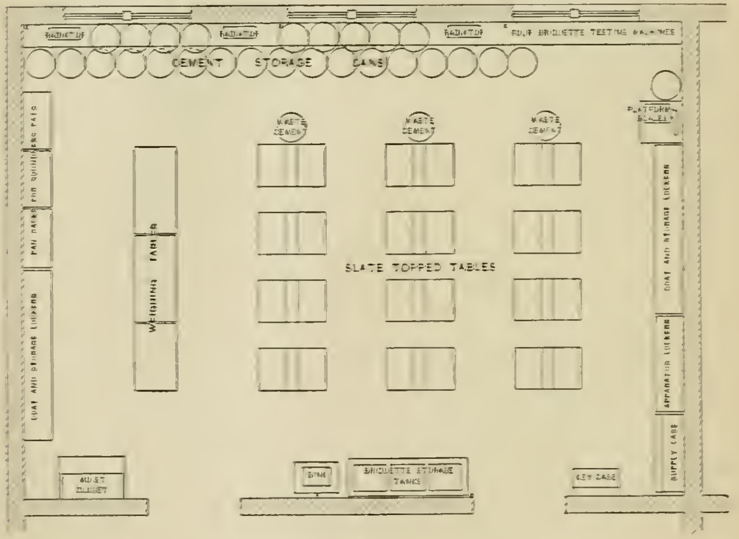


FIG. 1.

The laboratory at present nominally occupies a room 28 by 39 feet, although some of the apparatus is placed in an adjoining room which is chiefly devoted to the testing of road-building and paving materials. In the past the laboratory has changed location several times, depending upon the growth in number of students in this and other subjects, and this migration and the progressive growth of the laboratory have materially affected the character of the present equipment. Fig. 1, page 216, shows the floor plan of the present laboratory.

THE EQUIPMENT.

The cement is stored in galvanized iron cans holding a barrel. These cans are an outgrowth of the time when the laboratory was small and known to occupy quarters only temporarily. Such cans are satisfactory, except that they are more expensive in first cost and occupy more floor space than wooden bins built in sections. One half of the cover of the can is hinged about a diameter, and upon the fixed half is a rest such that the lid can not be left open. There are twenty-five cans for cement and five cans for sand. Each can is numbered and a description of the contents of each is stenciled on its side. The cans containing portland cement are numbered from 1 to 19, natural cement from 21 to 29, and puzzolan from 31 to 39. These numbers are used in assigning the experiments (see Table II., page 233). A new supply of cement is obtained each fall preceding the beginning of instruction in the laboratory. Ottawa standard sand, German standard sand, standard crushed quartz, and two grades of building sand are kept on hand—in cans numbered 41, 42, etc.

Fig. 2, page 218, shows the slate-top desk used by

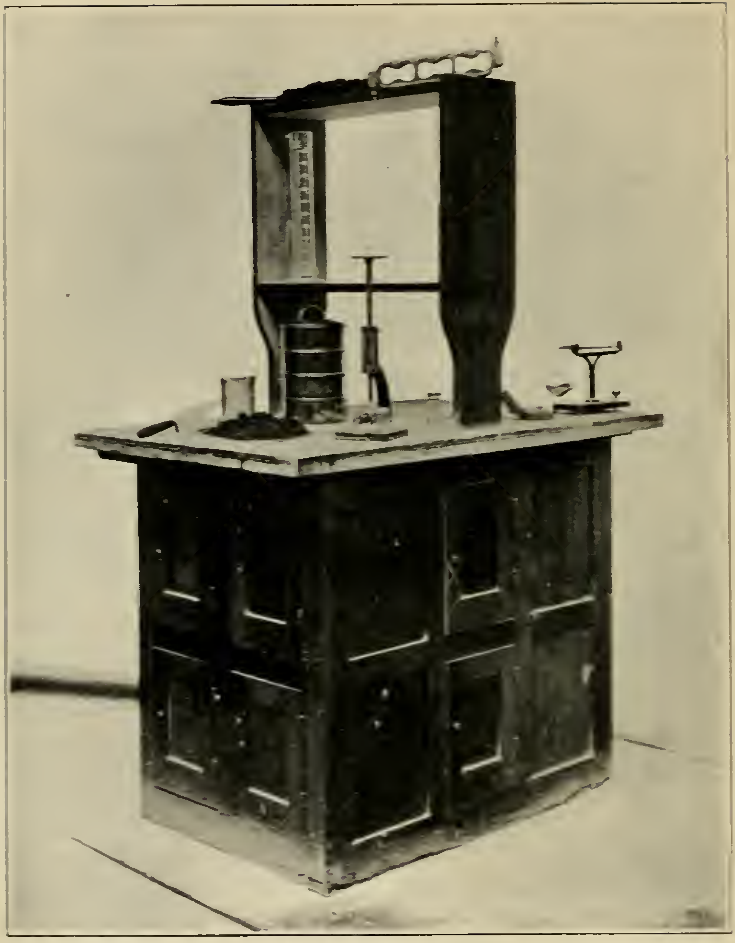


FIG. 2.

students. There are twelve such double desks, each containing twelve individual lockers; and thus the laboratory can accommodate six sections of twenty-four students each, and give each man a desk and a private locker. Each locker contains a 250-c.c. graduated glass cylinder, an aluminum beaker, a granite basin, and a trowel. The locker is large enough to permit the student to store therein an apron or overalls and jacket. The lockers are prominently numbered for convenience in assigning the same.

At one end of the room is a series of six lockers in which the students may hang their coats and overcoats, with a shelf upon which to lay hats and books. Adjoining these lockers are racks in which are placed galvanized pans to be used in the experiments for storing pats in air or under water, for storing briquettes, etc. At the opposite end of the room are six lockers for instructors' clothing and special apparatus. Another case of sixteen lockers contains the apparatus used in the experiments referred to later. At one side of the room is a soap-stone moist closet, a sink, and three lead-lined immersion tanks. Water is admitted at the bottom of the immersion tanks and flows out at the top, a slow current being maintained through the tank all the time. For convenience in storing briquettes in the immersion tanks, galvanized racks are provided having five shelves holding ten briquettes each.

The laboratory has six briquette-testing machines —Fairbanks' latest, Riehle's latest, the Faukeneau-Sinclair form, and an antiquated form each by Fairbanks, Riehle and Olsen. The laboratory has a single-hammer Boehme hand apparatus made in Germany, and a double-hammer power machine made by a local machinist. The latter is so arranged that it may be set for any number of blows, and when that number has been reached the machine will throw itself out of gear. In several particulars this machine is more satisfactory than the imported one.

There is also an Olsen press briquette-molding machine.

The laboratory has the following briquette molds: fifty individual molds fitted to both the Boehme machines and also to the Olsen press, twelve three-gang molds, eight six-gang molds, one twenty-gang mold and three thirty-gang molds. The two latter kinds were ordered several years ago of a local machinist because they were much cheaper than smaller gangs could be obtained elsewhere. The thirty-gang mold consists of six rows of five briquettes each. The molds are held together by a rod resting in a slot in the end of each section. The sections of the twenty and the thirty-gangs are interchangable, and rods are provided so that the molds may be used in gangs of five each, or in any multiple of five. Of course, individual molds or a small gang are preferable to so large a gang; but at the time they were ordered, it was believed that such a gang was the best that could be obtained for the money available.

In addition to the above apparatus, the laboratory has that referred to incidentally in connection with the problems to be described later.

THE PRACTICE.

The students have one two-hour laboratory period per week for ten weeks, and each performs ten experiments. The work is given in connection with the study of masonry construction; and is regularly taken by students in the courses of architectural engineering, civil engineering, and municipal and sanitary engineering, and occasionally by students in other engineering courses. A week preceding the first laboratory period each man is given five printed sheets containing certain general instructions and a detailed explanation of each experiment. Below is a copy of these instructions and explanations; and following are some comments thereon.

General Instructions.

The problems are fully described on the accompanying sheets; and these instructions should be carefully studied before coming to the laboratory.

In each case the brand of cement to be used is announced on the bulletin board in the laboratory [see Table II.]. Owing to lack of space, the cements are designated on the bulletin board by number only, but in the reports always designate the cements by name. Take no more cement from the can than is thought to be just enough for the experiment; and if any remains after completing the experiment do not attempt to return it to the original can, but put it into the can marked "waste cement."

At the close of the laboratory period put all individual apparatus into your locker, and leave all general apparatus clean and neatly placed on the desk.

The data and results, together with the necessary computations and explanation, are to be reported on eight and one-quarter by ten and three-quarter inch coördinate paper, ruled in tenths of inches and having a half inch unruled margin on three sides and three-quarter inch margin on the *left-hand* side. Put only one problem upon a sheet, and use only one sheet for a problem. Each report should show the number and title of the problem, the name of the student presenting the report, and the data called for in the statement of the problem.

The student is urged to take great pains to present the report in a neat form and to make all remarks terse, precise and complete. The preparation of the report is an important part of the work. The ability to make a report in which the data and results are clearly set forth in their proper order comes only by careful attention, and is well worth striving for.

The report should be submitted within three days after the problem is completed; and if so received, the report will be examined and returned before the succeeding laboratory exercise. Unless the report is presented by the fifth day, the student will not be permitted to take the next problem in the laboratory. All the reports are to be submitted at the final term examination.

PROBLEM ONE. FINENESS OF CEMENT.

1. Sift the sample of portland cement through a No. fifty sieve to remove any lumps; and weigh out either one hundred grams on the ordinary metric balance or one thousand units on the Riehle scale for testing the fineness of cement—preferably the latter. For accurate results the cement should be artificially dried, but that is impracticable in this case. Place the weighed portion on the No. two hundred sieve and attach the pan and the cover. Hold the sieve in one hand in a slightly inclined position, and move it back and forth, at the same time striking the side of it gently with the palm of the other hand, at the rate of about two hundred strokes per minute. Continue this operation until not more than one tenth of one per cent. passes through after one minute of continuous shaking. Weigh the portion left in the sieve and also that passing the sieve. Place the former upon the No. one hundred sieve, and repeat the above operations. Be careful not to injure the meshes of the sieves, particularly the No. two hundred, by rough handling.

Repeat the preceding operation for one other brand of portland and one of natural cement.

2. Tabulate the results to show the per cent. remaining upon each sieve and the per cent. passing the No. two hundred. Show also the per cent. of error for each cement.

Problem Two. Weight of Cement.

1. Determine the weight per cubic foot of one sample of portland and one of natural cement, by sifting each into the standard measuring box. Measure the size of the box.

2. Report the capacity of the box. Compute and tabulate the weights in pounds per bushel and also in pounds per cubic foot.

What are the chief sources of error in this problem? What is the estimated error of your results?

Problem Three. Specific Gravity.

The only value of determining the specific gravity of a cement is as a test for adulteration; but it is not very valuable for that purpose owing to the delicacy of the experiment and also to the fact that the adulterant may have the same specific gravity as the cement. However, as the determination of the specific gravity is frequently required, it is here included. Frequently the test is made with undried cement; but this is inaccurate, as cement long exposed to the air absorbs moisture.

Determine the specific gravity of an artficially dried sample and of an undried sample, *i. e.*, of a sample directly from the can. The specifications of the United States Army engineers require that the cement shall be exposed on a metal plate to a temperature of 212° F. for twenty minutes; but no harm will result if the temperature is considerably higher than 212° F., and therefore the cement may be dried on a metal plate over a small Bunsen burner.

While the sample is drying, determine the specific gravity of the undried sample. For accurate results the specific gravity flask should be immersed in water to prevent changes of temperature while making the test; but it is impracticable to do so in this case. The laboratory attendant will see that the benzine and flasks are placed upon the desk in sufficient time to have attained the temperature of the air at the beginning of the experiment. Be careful not to touch the body of the flask with the fingers any more than is absolutely necessary.

1. The specific gravity may be determined either with La

Chatelier's or Schumann's apparatus. (1) La Chatelier's apparatus has a large bulb at the bottom and a smaller one about midway up the stem. The volume from the mark below the bulb to that above the bulb is twenty cubic centimeters. (2) Schumann's apparatus consists of two parts, a bulb and a graduated tube, the latter fitting into the former. Moisten the surfaces of contact, and fit the tube into the bulb so that the joint will not leak. The method of graduation is apparent by inspection.

The specific gravity may be determined with either apparatus in either of two ways, viz.: (*a*) by finding the volume for a given weight; or, (*b*) by finding the weight of a given volume.

(*a*) Carefully weigh out, say, 65 grams of undried portland cement. Fill the apparatus with benzine to the zero mark of the graduation. Gradually introduce a part of the cement into the apparatus by means of a long-stem funnel. Proceed slowly so that the contained air may escape, and be careful that the cement does not come in contact with the interior surface of the tube. When the surface of the benzine has risen to, say, the twenty c.c. mark, remove the funnel and weight the remaining portion of the cement. Divide the weight of cement introduced by twenty, and the result will be the specific gravity of the cement.

(*b*) Introduce the remainder of the cement, and read the height of the benzine on the scale. This reading is the volume in cubic centimeters of the cement introduced. The weight of the cement in grams divided by its volume in cubic centimeters gives it specific gravity.

In emptying the apparatus, decant off the benzine into the bottle marked "used benzine," and then clean the apparatus by washing with water. Next shake out as much of the water as possible; and finally wash out the remaining water with benzine, *being careful to throw this benzine into the sink or stone waste-jar.* Be careful not to break the apparatus, as it cost $4.50.*

[* This is the amount we really paid, but we have since learned where we can get the apparatus for just half this sum.]

Remove the sample of portland cement from over the Bunsen burner and set it aside to cool. Put a sample of natural cement to dry, and proceed to determine the specific gravity of an undried sample of natural cement. Next determine the specific gravity of the dried samples of portland and natural cement. Be very careful that the artificially dried sample is cooled to the temperature of the atmosphere before using it.

2. Report the results and state the apparatus used. What is the estimated error of your results? What difficulties were encountered? What precautions should be taken? Does the specific gravity of the liquid employed affect the result? Could water be used? Alcohol? Turpentine? Kerosene? Gasoline?

PROBLEM FOUR. SOUNDNESS.

1. Make two pats of neat portland cement and one of natural cement, having a diameter of two or three inches, a thickness at the center of about a quarter of an inch, and thin edges. Mold the pats on a sheet of glass, and cover with a wet cloth, or better, place in the moist chamber. When set hard, place one cake in water, and allow the other to harden in the air. (If the pats have not set hard at the end of the laboratory period, the assistant in charge of the laboratory will on the morning following place one pat in the air and one in water.) Record the interval between mixing and immersing.

2. On returning to the laboratory for the next and several successive exercises, carefully examine the pats; and note whether any blotches appear, the character and significance of any cracks that appear, whether the edges curl up, and the time when the pat loosens from the glass. Any unusual result should be a subject for conference with the instructor. Finally submit a written report.

PROBLEM FIVE. NORMAL CONSISTENCY—BOULOGNE METHOD.

1. Determine by experiment the proper per cent. of water to be used in mixing neat-cement plastic mortar for experimental purposes.

2. Weigh out, say, 200 grams of portland cement and add the estimated amount of water (see data in Sec. 104, page 70, of the text-book). Work the mortar thoroughly and vigorously with a trowel on the slate table from three to five minutes. The inexperienced operator is very likely to use too much water and too little labor. To determine whether the mortar is of the proper consistency, apply the four tests mentioned in Sec. 103, page 70, of the text-book. If the paste is too dry and has not begun to set, add more water and repeat the tests; but to check the result, finally weigh out a new portion of cement and repeat the experiment.

Repeat the preceding operations with another portland cement and one natural cement.

How definitely can the proper proportion of water be determined, *i. e.,* what is the estimated probable error of each experiment?

3. Tabulate the results and state the estimated error.

Problem Six. Normal Consistency—Tetmajer Method.

1. Weigh out 500 grams of the portland cement used in problem five and mix paste of the supposed proper consistency, noting the per cent. of water used. Form the paste into a ball with the hands, and complete the operation by tossing it six times from one hand to the other, maintained six inches apart. Then press the ball into the ring of the Vicat apparatus through the larger opening, and smooth off the surface with a trowel; place the ring on its large end on a glass plate, and smooth off the smaller end with a trowel. Place the glass plate, the ring, and the mortar in the Vicat apparatus. Place the piston (diameter equals one centimeter or 0.4 inches) in the lower end of the sliding rod, and see that the cap marked "piston" is on the upper end of the sliding rod. Allow the piston to rest upon the surface of the mortar and read the scale; and then suddenly release the plunger and allow the piston to descend of its own weight. The mortar is of the proper consistency if the piston penetrates ten millimeters below the top of the mortar. (The scale is divided to millimeters.)

The penetration stated above is that required by the report of the committee of the American Society of Civil Engineers; but Tetmajer himself requires a plasticity such that the piston shall penetrate to within six millimeters of the bottom of the glass. What is the difference in the quantity of water required?

Repeat the above operation with another portland and a natural cement.

Record the results and conclusions to be derived from this experiment. Compare these results for plasticity with those obtained by the Boulogne method—problem five.

Problem Seven. Test of Activity.

1. Weigh out 500 grams of portland cement. For the approximate quantity of water required, see Sec. 104, page 70, of text-book; and for the exact quantity see the results of problems five and six. Mix a plastic mortar using water of from about 65° F. (19° C.) to 70° F. (21° C.). Record the temperature of both the air and water, and the time of adding the water. Make two pats upon separate sheets of glass. Place one of the pats in water having a temperature of 65° to 70° F., and allow the other to remain in the air. Note the time respectively when the two Gilmore wires are supported by each of these pats.

Using the same cement as above, fill the vulcanite ring (large end up) of the Vicat apparatus with plastic mortar and carefully smooth off the top. Place the needle in the lower end of the plunger, and the cap marked "Nadal" on the upper end. See that the bearings of the plunger are well oiled and that it moves freely; and see also that the needle is clean. Note the instant when the needle ceases completely to penetrate the mass and note also the time when the needle is just supported. The scale on the front of the apparatus will aid in determining the instant of initial and of hard set.

Repeat both operations as above with another portland and with one natural cement.

Empty the rings and clean the apparatus before leaving.

2. Tabulate the results, and give the interval for the Gilmore test and also for the Vicat test, elapsing from adding the water until initial set, and also until hard set. State your estimate of the probable error of the several intervals.

PROBLEM EIGHT. TENSILE STRENGTH—PLASTIC AND DRY MORTARS.

1. Use the gang molds. Before beginning the experiment, clean the molds and rub the surface which will come in contact with the briquette with an oily rag, and also slightly (but only slightly) oil the top of the slate slab where the gang molds are to be placed.

Mold five briquettes each of neat plastic and dry portland cement mortar, and also the same of natural cement. Use the same cements as in problems five and six. For the per cent. of water required to produce a *plastic* mortar, see the results of problems five and six, or Sec. 104, page 70, of the text-book; and for a *dry* neat mortar use 16 to 18 per cent. for portland, and 24 to 26 per cent. for natural cement. Record the per cent. of water used, and the interval elapsing from the time of adding the water until the first and the last briquettes are molded. (The last is recorded to show whether or not initial set had taken place before the last briquette was molded.) Cover the briquettes with several thicknesses of damp cloth and place the metal cover over all.

After about twenty hours the attendant in charge of the laboratory will place the briquettes in water.

Break the briquettes when seven days old.

2. Determine the tensile strength with a cement-testing machine. Be careful about centering the briquettes in the machine. Notice how the grips fit the briquettes—any defect? Note the approximate average time of applying the stress. Tabulate the results so as to show the strength of each briquette, and the mean for each brand and also its probable error. State the testing machine used.

PROBLEM NINE. TENSILE STRENGTH OF DRY MORTAR—DIFFERENT METHODS OF MACHINE MOLDING.

1. Use the individual molds. Clean the molds and oil the part that will come in contact with the briquette. Use portland cement and ordinary building sand; and mix a "dry" 1-to-3 mortar. For the per cent. of water required to produce a "dry" sand mortar, see Sec. 105, page 71, of the text-book. Make five briquettes by hand, five with the Boehme-apparatus, and five with the Olsen press. Weigh out 170 grams of mortar for each machine-molded briquette.

Record the per cent. of water used, and the interval from adding the water until (1) beginning to mold the first briquette, and (2) the completion of molding the last briquette. (The last is useful only to show whether or not initial set took place before the last briquette was molded.)

Store the briquettes without removing from the molds, in the moist closet or under a damp cloth in a clean bottomed tray. When about twenty hours old the attendant will remove the molds, and place the briquettes in water.

Break the briquettes when seven days old.

2. Report all the facts, and show the mean for each method of molding, and also the probable error of each mean. Specially mention any significant fact connected with the experiment. State the testing machine used.

PROBLEM TEN. TENSILE STRENGTH OF DRY MORTAR—DIFFERENT METHODS OF HAND MOLDING.

1. Use the gang molds, and in filling them be careful not to damage the edges. Oil the surface of the molds which will come in contact with the briquette, and also *slightly* oil the top of the slate slab where the gang molds are to be placed. Use "dry" neat portland cement mortar (for the amount of water required see statement of problem eight), and make from a single mixing five briquettes in each of the following ways: (1) by filling the mold and then pressing the mortar into place with the thumbs; (2) by filling the mold partially and pressing the mortar into place with the thumbs after adding each increment of mortar; (3) by ramming with an

oak rammer having a cross section of about $\frac{3}{4}'' \times \frac{3}{4}''$ and being about 12 inches long; (4) by ramming with a half-inch round iron rod one foot long; and (5) by using any other method of ramming that may suggest itself to the experimenter.

Record all significant facts observed during the experiment.

Cover the briquettes with a damp cloth and the metal cover, and when about twenty hours old the attendant will place them under water.

Break the briquettes when seven days old.

2. Report all facts, and show the strength of each briquette and the mean for each method of molding and also the probable error of each mean. State the testing machine used.

No forms for reporting the results are prescribed and no samples are posted. It is believed that students should learn to design the forms in which they report their work. In level notes or the notes of a railroad survey it is necessary to instruct the student to record his results in standard forms, since his record is likely to be used by others; but that reason does not apply to the records of the kind of work under consideration here. The reports are severely criticized, and if necessary returned for correction or rewriting. Attention is paid to the placing of the work upon the page, to the general typographic form, to the arrangement of the table, to the brevity and clearness of the explanations, to whether certain data should be included in the tables or in the accompanying explanations, etc. Between the first and second laboratory periods selected reports are taken before the class and commented upon to acquaint the student with what is considered good or bad form. The quality of the reports rapidly improves as the work progresses.

TABLE I.

Assignment of Problems.

Sec. E. Thursday, 10–12 a. m.

Ref. No.	Student.	Laboratory Period.									
		1	2	3	4	5	6	7	8	9	10
301	Bear, A. L.	1	3	5, 4	6	8m	7, 8b	9m	9b, 2	10m	10b
302	Brown, H. C.										
303	Burch, G. F.										
304	Burrough, W. G.	3	5, 4	6	8m	7, 8b	9m	9b,2	10m	10b	1
305	Campbell, S. C.										
306	Gonnerman, H. F.										
307	Grubel, E. A.	5, 4	6	8m	7, 8b	9m	9b, 2	10m	10b	1	3
308	Heaney, A. N.										
309	Howser, T. R.										
311	Hudson, H. H.	5, 4	8m	7, 8b	9m	9b, 2	10m	10b	1	3	6
312	Long, J. A.										
313	McCoy, M. H.										
314	Pierce, R. C.	8m, 4	8b, 7	9m	9b, 2	10m	10b	1	3	6	5
315	Slaymaker, C. M.										
316	Smith, C. H.										
317	Stinson, S. A.	5, 4	9m	9b, 2	10m	10b	1	3	6	8m	7, 8b
318	Warner, J. M.										
319	Webber, E. A.										
321	Ziesing H. H.	9b, 2	5, 4	10m	10b	1	3	6	8m	7, 8b	9m
322											
323											

It will be noticed that most of the problems require tests of both portland and natural cement. The statements of the problems have been in use for several years practically without revision, and when the statements were first prepared natural cement was relatively more important than now, particularly in the North Central States. Possibly the time has arrived when the student's attention should be concentrated to a greater degree upon portland cement; but even yet a knowledge of the comparative qualities of natural cement is valuable.

Table I. is a sample of the sheet showing the assignment of problems. The numbers in the body of the table refer to the problems described above. The suffix (*m*) means mold, and the suffix (*b*) means break; for example, 8*m* means mold the briquettes called for in problem eight. The reference numbers in the left-hand column are the numbers of the galvanized pans referred to previously. One third of them are numbered 101, 102, etc., and one-third 201, 202, etc., and one-third 301, 302, etc., the first figure indicating the section in which a particular pan is used, and the last designating the individual student using the pan. This may seem very elementary, but when a laboratory is used by 60 to 75 students per week considerable system is required to prevent confusion and loss of time by both student and instructor. A copy of the assignment is posted in the recitation room and also in the laboratory. Notice that three students perform the same experiment the same day. It would be ideal if each student could perform the experiments in numerical order, but this is not possible without having as many complete sets of apparatus as there are students in a section—an unjustifiable expense. The arrangement shown in Table I. is reasonably satisfactory, since it permits the student to take the experiments in a rational order, even if it is not the best order. Without increasing the sets of apparatus, the scheme shown in Table I. could readily be extended to include ten groups of three students each.

Table II., page 233, shows the assignment of the cements to be used by each student in each experiment. The assignment of the cement prevents the student's coming to the instructor to ask which

TABLE II.

ASSIGNMENT OF CEMENTS TO BE USED.

Sec. E. Thursday, 10–12 a. m.

Ref. No.	Student.	Number of the Problem.									
		1	2	3	4	5	6	7	8	9	10
301	Bear, A. L.	1, 2, 21	Same as Problem 1.	14, 15, 23, 24	Same as Problem 1.	6 24	Same as Problem 5.	Same as Problem 5.	Same as Problem 5.	7	11
302	Brown, H. C.										
303	Burch, G. F.										
304	Burrough, W. G.	3, 4, 22		1, 2, 24, 25		7 23				8	12
305	Campbell, S. C.										
306	Gonnerman, H. F.										
307	Grubel, E. A.	4, 5, 23		3, 4, 22, 23		1 21				9	13
308	Heany, A. N.										
309	Howser, T. R.										
311	Hudson, H. H.	6, 7, 24		4, 5, 24, 25		2 22				10	14
312	Long, J. A.										
313	McCoy, M. H.										
314	Pierce, R. C.	8, 9, 25		6, 7, 21, 22		3 23				11	15
315	Slaymaker, C. M.										
316	Smith, C. H.										
317	Stinson, S. A.	10, 11, 21		8, 9, 23, 24		4 24				12	16
318	Warner, J. M.										
319	Webber, E. A.										
321	Ziesing, H. H.	12, 13, 22		10, 11, 21, 25		5 25				23	17
322											
323											

cement to use, prevents the excessive use of the barrel most easy of access, acquaints the student with a wider range of brands, and secures a proper sequence in problems 5, 6 and 8. Some years the cements have been assigned by giving a student the same cements in all of his experiments. There are some advantages in each of these two methods of assignment.

The special apparatus required for the problem of the day is placed upon the student's desk by the laboratory attendant before the beginning of the class exercise. This saves the student's time and prevents the confusion that would result if each student came to the storage locker for his apparatus. The attendant has a copy of Table I. from which he can readily determine the problem any student is to have each day and also the number of his locker and of his desk; and therefore the placing of the apparatus does not require much of the attendant's time, and the benefit abundantly justifies the expense.

The attempt was formerly made to have each student leave all apparatus clean, but after a little experience it was found to be better for several reasons to permit a student to leave the apparatus dirty and require his successor to clean it before using it.

It will be noticed that the cement paste is to be mixed with a trowel on the slate desk top, as in the French specifications, instead of being kneaded with the hands as prescribed by the specifications of the American Society for Testing Materials. If the mixing is to be done by kneading with the hands, rubber gloves should be provided, which is impracticable for so many students; and besides the kneading process is not as quickly learned, and the beginner is so dainty about it that the results are far from satisfactory. Further, the mixing with the trowel is better for neat cement, since when mixing by kneading a film of paste adheres to the hand and is thereby dried out; and besides the entrained air is more easily expelled from the neat paste than from a sand mortar. The student is instructed as to the requirements of the standard specifications; and in all commercial testing and research work done in the laboratory the kneading process is used. In making sand briquettes the mortar is mixed by kneading according to the method prescribed in the standard specifications.

Formerly the students were required, in addition to the problems enumerated above, to work several others which were in the nature of elementary research; but owing to the demands of other subjects upon their time the amount of work in the cement laboratory was reduced to that stated above. Some of the subjects formerly included are: effect of age upon neat cement and also upon sand mortars; effect of different per cents. of water upon the tensile strength of different cements; difference in the tensile strength between mixing with a trowel and by kneading with the hands; compressive strength of cubes and of cylinders; transverse strength of bars; comparative strength by different methods of hand molding; accurate determination of the probable error of hand molding; and accelerated tests of soundness. The probabilities are that it would have been wiser to have excluded the specific gravity tests and to have included some of the experiments just mentioned.

It is not claimed that the preceding amount of practice makes the student an expert cement tester; but it is believed that it gives him a reasonably good understanding of some of the qualities of hydraulic cement and familiarizes him with the methods employed in testing it. A considerable number of students do additional work with cement in the laboratory in connection with their theses.

An experienced instructor and an expert in cement testing is in continual attendance during class time; and each is usually busy, particularly during the first few laboratory periods. The problems are corrected outside of the laboratory period. A laboratory manual or guide would be of advantage in this work, and the writer has for some years had in mind the preparation of such a manual but has not had opportunity even to begin it.

DISCUSSION.

PROFESSOR BOYD: I noticed that practically all the tests were on briquettes. We have found it advantageous to give students a little testing to do on larger quantities, each one making up two 5″ x 6″ beams—one plain, and the other of reenforced concrete. This gives the student a little practice in mixing the concrete and in handling it. It is one thing to mix cement with a trowel in a small quantity, with any amount of time, and another thing to mix a larger quantity with a shovel. With very little time, this is something which we can let them do, the handling of the cement, and also the testing of the beams, and then they see the difference between the plain concrete beam and the reenforced beam.

DEAN KENT: It seems that one of the greatest troubles with cement is to get rid of the personal equation. You have a barrel of cement and a dozen students sampling it and they get almost all kinds of results. It is a question whether this is due to the quality of the cement or to a personal equation. Investigations of this matter should be made by the cement laboratories. It would be advisable, if possible, to improve our methods of testing cement in order to get rid of the personal equation, so that if we send a barrel of cement to two different laboratories we get the same results from both the laboratories.

Professor Williston: Using full sized samples, and low grade rather than rich mortars largely eliminates the irregularity due to the lack of skill of students or to their personal equations. In dealing with the small quantities of cement it is very hard to get the mortars mixed exactly right, and in dealing with the rich mortars it is often difficult to prevent too rapid setting. These things cause an irregularity. On the other hand, with the larger quantities and shovels it is possible to get much more uniform and reliable results, and for this reason at Pratt Institute we have almost entirely discarded the use of small specimens and briquettes, and use instead for nearly all the work good sized specimens, cubes six or eight inches square, or larger, and beams, reenforced and not reenforced. We find that the results obtained with these are much more uniform than we were ever able to obtain with small samples.

HOW FAR IS PURE THERMODYNAMICS OF VALUE IN PREPARING STUDENTS FOR HANDLING MECHANICAL ENGINEERING PROBLEMS.

BY ARTHUR J. WOOD,

Associate Professor of Experimental Engineering,
The Pennsylvania State College.

This subject may at once suggest a renewal of many fruitless, but pointed discussion on theory *vs.* practice; but no real conflict now exists in engineering schools as a whole, between what were once regarded as two mutually inconsistent ideas.

I take it that pure thermodynamics refers to the unadulterated theory, more particularly to the mathematical analysis; to the science, rather than to its direct applications. The present tendency in engineering courses is to avoid the teaching of pure theory in this subject. Bearing in mind the preparation of the student, and the purpose—or lack of definite purpose—which leads many to take an engineering course, opinions may differ on the main question as to whether or not this tendency is in the right direction; but there can be no disagreement on the point that but a small amount of mathematical theory is absolutely essential in order to handle the more common engineering problems in thermodynamics. On the other hand, a certain amount must be taught, and a still larger amount is highly desirable. Mathematics is here not an end in itself. The all-important object is for the student to see the fact, the truth, the law.

Ten years ago, Professor Lanza stated before this Society that "we wish, as far as any education can accomplish it, to fit the student as thoroughly as possible, to meet and grapple successfully with the duties of his profession, including the problems of a technical nature, which he will be liable to meet in the practice of his profession, and also the responsibilities that he will have to assume as an engineer and as a man."

While the teaching of thermodynamics since then has been the target for criticism, sometimes just, but often abusive, it has undergone some changes of methods made necessary by the very rapid development in its principal applications—notably to steam turbines and gas engines—and, also, by the general introduction of the entropy-temperature diagrams; yet the aim expressed by Professor Lanza is as pertinent today as ever, and must be reckoned with when eliminating from the course this fine mathematical analysis which gives great mental reach, even though it may have no specific application to the several substances available for transforming heat into work.

The writer is in accord with the general aim to make the teaching practical, but is unalterably opposed to what may be called the *substitution* method of using engineering equations, believing that this leads to the following well-defined evils: (*a*) using terms but not knowing the significance of operations, (*b*) many errors in substitution, (*c*) a narrow and distorted view-point. These may be illustrated in the order named.

(*a*) We know that if a pound of liquid, as ammonia, expands adiabatically through a nozzle, from a higher to a lower pressure, there is a certain percentage of that pound which will of necessity be vaporized at the lower pressure in the nozzle, the exact amount depending primarily on the pressures. The engineer or the student working a problem involving this general principle, may apply his formula and obtain correct results, while knowing nothing of the theory. But let him turn from this to a problem involving compression of a vapor mixed with liquid instead of expansion from a liquid. The same formula may be applied, but if one is not sufficiently familiar with the theory to know the significance of the operations expressed, as well as of the symbols used, the result may well be called in question. Why compromise all standards and respect for sound learning, by teaching that it is enough to know what the terms mean and how they are used? Yet, is not this or its equivalent being done, to our knowledge, every day?

(*b*) In plotting entropy-temperature diagrams of a gas-engine, a formula may be derived for the entropy between two points, involving changes of both pressure and volume. In this particular instance, the change of entropy must be calculated from the formula representing the law of that particular expansion. Shall we teach pure theory, or is good judgment sufficient for its right application? If the latter, the same kind of well-known errors may be made, as in the blind application of the simple but all important expression, $PV = MRT$. Unless one sees the physical law expressed, the mark is missed and the subject falls into ill-repute.

(*c*) A more familiar example, and one that illustrates the evil of leading to a narrow and often distorted view of the subject, may be noted. An oft-repeated remark by the student in the laboratory is: "I now see what all the symbols used mean, in this throttling calorimeter formula, but fail to understand it as a whole." The difficulty may have come through a different system of notation from that used in his text-book, but more often follows an attempt to memorize. When he is shown that he must have a balance of heat on the steam-pipe line and in the calorimeter, he has the cue, and only when he can write it down for himself in any notation, will the subject begin to have a real significance.

These commonplace illustrations, referring to three well known evils, may be extended into the field of pure theory, involving those complex equations of the adiabatics of imperfect gases. How many engineering schools teach this part of the subject? Some who do not, have said that the student, believing it to be his sacred duty to forget it all immediately after examinations, will not be able to use it in the problems which he will meet in the practice of his profession, and further that the student does not take hold of it with the eagerness and enthusiasm, born of a live interest, like that shown in problems in engineering practice. Is this a sufficient apology for half teaching one of the most important subjects in the whole mechanical engineering course? It makes for a cheap product and may reflect more on the teacher than on the subject or the student. If the policy of the institution will not uphold a rigid requirement, in the regular course, the advanced theory may be taught at least to those who will turn out to be something more than a *substitution* engineer. At the spring meeting of the American Society of Mechanical Engineers in 1897, a member of that society presented a short paper on "adiabatics," bringing out some new relations developed mathematically. It called forth a discussion on graphical as against analytical methods which has been continued at times ever since, with no serious injury to either method. A certain member was requested to prepare a paper for a later meeting to show how such abstract and involved relations could be represented graphically to the eye by entropy-temperature diagrams. He prepared a clean cut, valuable paper, but the relations derived in the original paper were not shown graphically and it is fair to say in this case that this could not have been done to advantage. This is no fault of the graphics, but rather is because the mathematics is the natural and accurate medium to use in reaching the final results. Other instances might be cited, not disparaging to the teaching of the entropy-temperature analysis, which clears up many a befogging and lifeless mathematical expression, but rather to emphasize the point that nothing is to be gained in most cases by depending upon the latter methods to the absolute exclusion of the mathematics. I wish to make it clear, that if it is a question on the one hand of thoroughly comprehending a few thermodynamic laws and their uses, or on the other of getting one or two coats of whitewash of mathematical formulas in order to turn out a product smoothly finished and highly polished, let us hold to the former every time.

From the teacher's standpoint, however, two facts are ever facing him: first, if a student has spent three college years with his mathematics, why wilfully avoid its use when it opens up a most accurate conception of many of the laws of heat? Someone will be careful to remind us that very many students do not have the mental makeup to really comprehend the abstractions expressed in the fundamental equations of thermodynamics:

$$dH = c_v dT + T\left(\frac{dp}{dT}\right)dv,$$

$$dH = c_p dT - T\left(\frac{dv}{dT}\right)dp.$$

Time has long since passed when it is true to use the words "cannot comprehend," in connection with these expressed universal laws of nature. I have more than once observed students, having caught the far-reaching significance of the above expressions, turn from indifference to genuine devotion and enthusiasm in the study of the subject. If a student has not the mental stock to grasp their meaning, then the action of imperfect gases can never be fully understood and appreciated by him. I would have every student go slow enough to see for himself something of their significance and to have him know that they are intensely active issues in his professional life. One who has time only to apply such formulas, or an expression derived from them, without knowing their significance, is not really practical, for he knows neither their limitations nor their possibilities.

Thermodynamics is having such widespread application and is developing so rapidly, that time should be given in every engineering course for covering thoroughly the elementary theory. Surely the student will never master the subject after leaving college; but, if he is in engineering practice, he will constantly come in touch with its applications, even though he may not be directly dependent upon them for his living.

My suggestion for the most desirable and effective arrangement in a mechanical engineering course of college grade for subjects pertaining to heat engines, and thermodynamics is as follows: The theory of heat taught thoroughly in the sophomore year; the study of heat engines, including the elementary thermodynamics, in the junior year; the pure theory, covering all the working fluids, developed from the fundamental equations, with problems in gas and steam engine, steam turbines, refrigerating machines, and the like, in the first semester of the senior year; and the separate and more thorough study of the special engines either parallel with this study of pure theory, or preferably later in the senior year. This separate study of subjects should include problems worked by the students, using the entropy-temperature analysis, the usual prescribed laboratory course being followed along with the class-room studies and closely related to them. This applied work ought to be made a part of the verification of the theory. In the second semester, I would have an option course in advanced theory, for those who wish to train for leadership in developing the science. If properly taught in such sequence, thermodynamics need not be regarded as the most "headless, tailless, soulless, and profitless bugbear of the whole engineering course."

Further, for electrical and mining engineers, the same general arrangement of the work may be adhered to, except as to the amount possible in the senior year, and the whole may be directed more toward power plant management and design. Civil engineers can obtain but little from an abridged course unless accompanied by practical work and this should come preferably in the junior year.

It is now half a century since the giant-like processes of Rankin, Clausius and Thomson (Kelvin) began to mould the thought of the world along newly discovered paths of pure science. Their practical applications to heat engines have played an important rôle in the far-reaching developments of the past fifty years, and yet, may we not believe, have only begun to accomplish the results made possible directly by the development of their theory. Take this away from the study of vapor engines of all descriptions, from air motors, and refrigerating machinery, and what have we left? Their works are classics in engineering and may well be studied for their true cultural values as well as for their science.

In conclusion, I ask, therefore, "Does not the future demand that the tendency shall be towards teaching more, rather than less, of the theory of thermodynamics, and will not such teaching make for a stronger and more progressive type of engineer?"

DISCUSSION.

DEAN KENT: Professor Wood's paper ought to be carefully studied by those teaching the theory of heat. I think it is not advisable to give this severe course in thermodynamics to all undergraduate students, but it would be an excellent study as an elective in the fifth year of a five year course. If a student wanted to specialize in thermodynamics, Professor Wood's course would be an admirable one, but for the thousands of students going through our colleges today it would be a great waste of time. We have all we can now manage without going into differential equations; and I have left out the differential equations entirely from the course, going to the extreme, perhaps, in one direction as Professor Wood has done in another. It has been said that *truth* lies between two extremes.

DEAN GOSS: I accept this paper as a direct plea for graduate work in engineering, a matter to which our engineering colleges have thus far given too little attention. Our whole effort has been to prepare men for the active work of their chosen profession. There is ample evidence in this meeting that there are other things for which students in engineering should be trained. It is with great satisfaction that I have read in the newspapers of one of our leading institutions offering a well-defined course leading to the degree of educator of engineering. That is along the right lines, and the time is not far distant when many such courses will be offered and taken.

PROFESSOR WEBB: I want to express an opinion about the teaching of thermodynamics. It would be better understood if it is taught from Rankin's standpoint, with a thorough understanding of Rankin's statement of the second law. It has always been a very interesting remembrance to me from the time when I studied Clausius's work on the subject. He produces a fundamental formula in which he first gets the form of the function, and proves that the formula must be the same for all substances; consequently, he says, we may get the values of the terms by an experiment on any one of those substances, and then he gets it by taking a perfect gas, which is an imaginary substance unknown in nature. There is therefore a break in the logic.

DEAN EDDY: We have a class in thermodynamics every year of thirty or forty students. I have usually at the conclusion of the course asked an opinion of the class whether the subject appeared to them abstruse and difficult of understanding, or whether they understood it and thought that they were able to apply it as they would any of the other physical or mechanical theories that they were familiar with. They have uniformly responded that they did not regard it as abstruse or difficult of application, or that they were uncertain about the applications of the method or the computations. The course occupies three hours a week for a semester, and at the conclusion of it they construct from experiment entropy-temperature diagrams for the steam engine and gas engine, but the course does not consist especially of that particular kind of work; it deals principally with the physical facts to be expressed in mathematical or in graphical language, or in any other way that will properly arrive at or express the relationships of thermodynamics. I see no more impracticability or difficulty in making clear the necessary relationships of thermodynamics than in anything else. The mathematical difficulties bear no comparison whatever with those of alternating currents, and I believe it is entirely within the range of ordinary undergraduate instruction. In this experience with large classes year by year, I think perhaps an ounce of experience is worth a pound of theorizing on the subject.

ON ENTROPY.

BY WILLIAM D. ENNIS,
Professor of Mechanical Engineering in the Polytechnic
Institute of Brooklyn.

Entropy cannot be defined in physical terms. It is a unit for measuring something that we cannot see, feel or hear. While related to mass, it is a function of so many other variables that we cannot describe it in terms of mass. The only difficulty with entropy, however, arises from the *attempt to define it.* Indeed, all difficulty would be avoided if we would content ourselves, not merely with not defining, but with not even naming it. The immense usefulness of the temperature-entropy diagram may be realized to the full extent without imposing any necessity for defining either logically or physically the horizontal coordinate of that diagram.

Too much has been written on the difficulty of the subject. Professor Wood published a pamphlet entitled "Entropy; An Abstruse Subject." A recent writer mentioned it as an example of the purely abstract conceptions that occasionally encumber engineering studies. Rankine suggests it in too terse a way for the average student's comprehension. None of these writers makes any reference to the convenience of the temperature-entropy diagram for the solution of the most definite practical problems. Mr. George Richmond* has printed a most admirable monograph on the diagram, including an extended reference to its bibliography, so far as that bibliography extended ten years ago. More recently the articles of Professor Reeve bring the subject down to the comprehension of men of the most limited education.

---

* *Trans. A. S. M. E.*, XIX., p. 477.

With a few exceptions, the whole body of principles which constitute the science of thermodynamics may be unfolded without use of the calculus. In fact, as taught by means of the temperature-entropy diagram, a satisfactory course in engineering thermodynamics can be given with but two applications of the integral method. One of these arises in determining the external work done during isothermal expansion, the other in establishing the form of the entropy-temperature curve for a liquid. In both cases, all the knowledge of calculus required is that necessary to perform the operation

$$\int \frac{dx}{x} = \log_e x.$$

This is elementary knowledge, indeed. The elaborate forms of integration for vapor adiabatics, and other mathematical exercises common in the pages of Wood and earlier writers, are entirely unnecessary. If they are valuable as mental training, they should be taught in the mathematics departments. The results to which they lead may be derived with greater simplicity by means of temperature-entropy analysis. The real difficulty with students first approaching the subject is not in the mathematics, however, but in an adequate perception of the physical meaning of the principles considered. In order to have it properly precede the detailed study of prime movers, the subject of thermodynamics must usually be taken up early in the junior year. Thus a course of extreme difficulty must be undertaken by men of immature age, who thus far have been doing little deep thinking. Concurrently with thermodynamics, they are obliged in most cases to begin the study of another difficult branch, that of applied mechanics. Their mathematical difficulties are not serious; only the easiest operations in calculus are required, and if the students are ever deficient on the side of mathematics it is in the quick transformation of simple trigonometrical and exponential equations, and in arithmetical computations involving the extraction of fractional roots by means of logarithms having negative characteristics.

Great inefficiency arises from faulty arithmetic. The subject is usually taught in the grade schools and forgotten in the high or preparatory schools. Men who can obtain the volume of an ellipsoid by integration fail in pointing off decimal quantities.

In aiming at the more serious problem suggested, it is desirable that the student should at the outset study something of the history of the development of heat motors. He thus learns from the practical side how progress has been obtained by expansion, condensation, increase of initial pressure, and other means, and is prepared to find theories developed which account quantitatively for these gains. Besides all this, he learns definitely and physically what, for example, condensation actually is. It might be quite possible for him, otherwise, to faithfully study thermodynamics without having any very clear notion on the matter. A further aid in the teaching is to plan the laboratory and the thermodynamics courses together, so that the one may furnish exemplifications of the principles developed in the other. Still another method is to teach principles arithmetically as well as algebraically. Too many men, confronted with a problem, search for a formula. If the formula be lost, all is lost. In the study of the throttling calorimeter, for example, therefore, let the formula be discarded; it is not desirable that the student should try to remember that

$$ql + h = l_1 + h_1 + \kappa \cdot (T_2 - T_1)$$

but it is of vital importance that he know that the total quantity of heat in the steam is the same on both sides the orifice. With this knowledge he may cease to "substitute in the formula," and compute results arithmetically and directly. Frequent numerical problems, with a disparagement of memorizing methods, facilitate the attainment of this position.

The logical development of the temperature-entropy diagram has all the definiteness of a series of propositions in geometry. As a preliminary, the representation of expansions on coordinate diagrams must be described, with special reference to those on the pressure-volume planes. Then let the adiabatic be defined, with abundant illustration from assumed practice and comparison with the isothermal. We follow with these theorems:

1. On the *P-V* diagram, the external work done along any path is represented by the area subtended

between that path and the base. This is readily shown by dividing the area into vertical strips of infinitesimal width. Then, since work equals force times distance, the work shown by each strip is PdV, P being sensibly constant: and the total work, or $\int PdV$, is the summation of the strips.

2. On the P-V diagram, the external work done during a closed cycle is represented by the area of the cycle. This follows directly from Theorem 1.

3. On the P-V diagram, the heat absorbed along any path is represented by the area between that path and the two adiabatics indefinitely extended to the right. This area is included in a series of paths forming a closed cycle; hence, from Theorem 1, the area represents the external work done. Since the substance is brought back to its initial condition, the summation of changes of internal energy is zero: consequently the external work must equal the heat absorbed. From the definition of an adiabatic, all of the heat absorbed must have been absorbed along the assumed path: and this heat is therefore represented by the area of the cycle.

4. On the P-V diagram, the efficiency of a Carnot cycle is equal to the quotient of the area of the cycle by the area between the upper isothermal and the two adiabatics indefinitely extended to the right. Since efficiency is work done divided by gross heat absorbed, the proposition is self-evident.

5. Carnot cycles through equal temperature ranges afford equal amounts of external work. This is a slightly simplified form of Rankine's statement of the second law of thermodynamics. If not self-evident, it is readily proven by dividing the entire area

between two adiabatics by equidistant isothermals, and expressing the efficiency of each cycle. From the indefinite right to the topmost isothermal gives 100 per cent. efficiency. Using the topmost isothermal as that of heat absorption, let the rejection isothermals ascend from the indefinite right by equal increments. The gross heat absorbed is the same in all cycles, but the efficiency and the work done are decreasing by increments equal to the increasing increments of rejection temperatures.

At this stage the student may be expected to deduce for himself the principle that any path whatever exerts an influence on the cyclic efficiency which is measured by the quotient of added cyclic area by added area of heat absorption. He then sees the impossibility of measuring the latter of these two areas by any graphical method. He finds that the work area, which is within finite bounds, can be readily computed or measured. The heat area can only be obtained by integration. He notes the necessity of a measurable heat area, permitting of the direct determination of efficiencies. At this point his attention may be called again to the equality of the Carnot cycles, shown in Theorem 5. Each of these cycles is bounded by isothermals and adiabatics, forming a distorted rectangle. Ignoring the distortion, if the isothermals are equidistant by measurement as well as numerically, the widths of the rectangles must be equal: or the distance between the two adiabatics, measured along an isothermal, must be uniform.

We may then construct a diagram in which these rectangles are "straightened out," as it were. Let it be turned clockwise so that the isothermals lie horizontally, and the adiabatics vertically. Vertical distances then represent temperatures. Let the adiabatics be projected downward to a base line which we will make the absolute zero of temperature. The vertical scale is now one of absolute temperatures. Areas on the diagram subtended between any isothermal and the base line, are to represent heat quantities, absorbed or rejected along the isothermal. Adiabatics must lie vertically, in order that they may subtend no heat areas. The vertical scale of isothermals must then be divided into intervals both numerically and measurably equal, since all the rectangles are to be equal. Each rectangle is a Carnot cycle. Theorems 2, 3, 4 and 5 are now seen to be obviously applicable to this new diagram. The diagram is called the temperature-entropy diagram, temperatures being ordinates and quantities of heat absorbed being areas. The horizontal distance we call entropy. It is the distance between two adiabatics. To reduce entropies to a convenient scale, we consider the adiabatic for a temperature of 32° F., atmospheric pressure, and normal volume, to be the vertical coordinate axis. Distances from this adiabatic to any other then give absolute measurements of entropy. The entropy itself is nothing but a name of an abstraction, the quotient of heat quantity by temperature.

The argument thus far is that of a series of problems in construction. We may subdivide it thus:

(*a*) Represent on a coordinate diagram, in which subtended areas are heats absorbed and ordinates are temperatures, an isothermal and an adiabatic. Since the isothermal is a path of constant temperature, it must be horizontal. Since the adiabatic is a path of no heat transmission, it must be vertical.

(*b*) From Theorem 5, how must the temperatures be scaled in order that they may divide the heat areas equally? Obviously, in equal intervals.

(*c*) In what units is the horizontal scale divided? If areas are to be in heat units, and ordinates in degrees, abcissae must be in heat units per degree. Assuming an isothermal path, equal heat areas are subtended by equal abcissae, so that horizontal intervals must be equal.

(*d*) Find the entropy added in evaporating one pound of water at atmospheric pressure. The heat area must be 966 B.T.U. The temperature is 212° F. or 673° absolute. The entropy is then

$$966 \div 673 = 1.435.$$

(*e*) Find the entropy added in heating one pound of water from 32° to 212°. In this case the temperature is variable, the total quantity of heat absorbed is $K(212-32)$, or generally $\kappa(T_1 - T_2)$. The general expression for entropy is $\int dh/T$ or, for water, sensibly

$$\int_{T_1}^{T_2} \frac{dT}{T} = \log_e T_2 - \log_e T_1 = .314 \text{ B.T.U.}$$

It is now easy to extend the calculations so as to readily derive and tabulate the entropies for superheated steam, wet steam, ice, etc., for various pressures and temperatures. The student is not asked to define entropy, but simply to use it. He may take, for example, an indicator card from an engine without expansion. He shows on the *P-V* diagram the increased work effects resulting from increased steam pressure, superheat, expansion, complete expansion and condensation. He is asked to state what compensating disadvantages tend to offset the gains shown. These he describes in a more or less inadequate and qualitative way. The entropy diagram is then suggested and by actual measurement the exact increment of efficiency theoretically possible is shown for each modification studied. He takes the principle that superheat lowers the efficiency of a refrigerating machine, and after some floundering, resorts to the entropy diagram and computes to a nicety what the detrimental effect is under stated conditions. A large class may be found busy with the most practical sort of entropy calculations. If asked to define the term, they would hesitate, and then express it as a quotient of quantities shown on the diagram. And this, after all, is the only way in which any one can define it.

The only difficulty with entropy is in the name. The application to problems of design and operation is fundamental and extensive. Far more difficulty is found with other less immediately practical aspects of thermodynamics. The criterion of reversibility, the theory of ammonia absorption machines, and the construction of the release line for 90 degree compound engines all give infinitely more trouble.

ON THE CONCENTRIC METHOD OF EDUCATION IN ENGINEERING.

BY V. KARAPETOFF,

Professor of Experimental Electrical Engineering, Cornell University.

> "No profit grows where is no pleasure ta'en. In brief, sir, study what you most affect."—*The Taming of the Shrew.*

A year ago the author presented before the American Institute of Electrical Engineers a paper "On the Concentric Method of Teaching Electrical Engineering," in which he pointed out certain shortcomings in methods of teaching engineering now in vogue, and outlined a somewhat different, so-called *concentric,* arrangement of courses. The paper aroused discussion in the Institute and in the press, and it has seemed proper to give the method wider publicity. The purpose of this second paper is to present in concise form the principles of the concentric method and the arguments in its favor. The subject is treated under two headings: (A) What to Teach, and (B) How to Teach.

A. WHAT TO TEACH.

I. *Two Extreme Views.*—The idea of the trade-school and the idea of general culture.

First—The trade-school education consists in teaching practical details of a branch of engineering so that the student after leaving the school may have immediately a certain market value in subordinate positions. The theory and underlying principles of the profession are allotted only a small place, and the general culture studies are reduced to a minimum. While such schools undoubtedly are necessary for producing skilled mechanics, foremen, etc., some people advocate the same methods for colleges of engineering.

Second—The broad-culture idea is based on the principle of a systematic training of the mind, independent of the future profession. The advocates of this method claim that a well-educated man will find himself at ease in any new situation, and will acquire the necessary routine skill and professional knowledge in a very short time. According to this idea, a future engineer ought to be taught in college plenty of mathematics, physics, languages and literature, political economy, etc., and only very little of engineering proper, all practical details being entirely excluded from the curriculum.

II. *A Combination Course.*—A five-year course for electrical engineers. Both views are one-sided: Man's development from childhood to maturity must be organic, harmonious and uninterrupted; the school must plant the seeds of all the functions for man's future activity. Therefore, the curriculum of a good college of engineering must comprise:

(*a*) The fundamentals of the profession proper, including its theory and practice.

(*b*) A fair amount of information concerning the allied professions.

(*c*) Such auxiliary sciences as are necessary for the understanding and the development of the profession.

(*d*) A certain amount of broad general culture.

A sample schedule of studies according to these requirements is shown in the form of a table at the end of the article, in application to a five-year course in electrical engineering.* Four principal groups of studies are there distinguished: electrical engineering proper; mechanical engineering, as a closely allied branch; auxiliary sciences, such as mathematics, physics and chemistry; and history and political science. A reasonable amount of time is also left for broad culture. The reasons for the particular distribution of the subjects are explained in the second part of the article, under the heading of "How to Teach."

The following arguments may be urged in favor of teaching the practical side of the profession in college:

(*a*) The fundamentals of any profession should be taught systematically, and not "picked up as the man goes along" in his practical work. A thorough knowledge of fundamentals opens up an easier way for future professional development. The school is the proper place for teaching fundamentals systematically. These fundamentals should not be confused with auxiliary sciences, such as physics, mathematics or chemistry. They are the general principles of the profession itself, such as the action of steam in a cylinder, the bending of beams, the general scheme of generation and transmission of power, classification of machine tools, etc.

---

* The question of either raising entrance requirements, or increasing the length of the course from four to five years, has lately been taken up by several leading technical schools in this country; and no doubt the longer course will be inaugurated in the near future. This has become necessary because of the wonderful growth of the engineering art, and also because of the increased responsibilities and higher social standing of engineers. Cornell University offers now, besides the regular four-year course in engineering, an optional five-year course.

(*b*) A study of the profession lends interest to the effort given to auxiliary sciences; it also makes the study more fruitful, as the student sees the direct bearing of his studies upon his future activity. For this reason a general outline of the profession should somewhat precede, in the schedule, the study of physics and mathematics.

(*c*) A student who has been well grounded in the elements of his profession during his course has a certain value on the market immediately after graduation.

(*d*) Even granting that the principal purpose of college work is the training of the mind in logical thinking, there is no reason why such training cannot be achieved by properly teaching the profession itself.

III. *The Definition of General Culture.*—The correct definition of general culture is based on the fact that man's life is divided between furnishing services to and receiving services from society. *General culture comprises such studies as better enable a man to receive and to enjoy services from society, while professional training enables him to give better service to society.* From this point of view, the same subject may be taught either as general culture or as a preparation for professional activity, the difference being in the method and in the scope of study.

Some persons define general culture as *that which a man knows superficially.* This is wrong; the habit of knowing anything superficially is detrimental to the mind and must be eradicated, and not fostered in good education.

The skeptical definition of general culture as *things useless in practical life* is also unsatisfactory. There is no division of life into practical and theoretical; there is but one life, of which all our acts and thoughts are but particular manifestations. General culture that enables a man to judge keenly, to act nobly, cannot be called of no practical value.

According to the distinction between professional training and general culture, given above, the professional training of an engineer must comprise not only engineering proper, but the elements of political and economic sciences as well, because these latter also enable him to give better service to society. The growing demand for clean politics, and for public control or ownership of public utilities, requires more and more knowledge of social and political science on the part of every intelligent citizen. The subjects which may be comprised under general culture for engineers are: languages, literature, philosophy, history, psychology, biology, music, painting, physical culture, and athletics; and, in a lower degree, mathematics, physics, chemistry, geology, astronomy, etc. Those who are specially inclined may derive a good deal of pleasure from a general study of applied sciences, such as medicine, jurisprudence, and agriculture.

The following arguments may be advanced in favor of giving engineering students an opportunity for pursuing, during their college years, such disciplines as those just mentioned:

(*a*) The country owes to the new generation every opportunity for the fullest development of their capacities as individuals and as members of the society; to do so raises the moral and the intellectual standard of the country.

(*b*) The right seeds of general culture, as of any other human activity, must be planted thoroughly and systematically. This is done best in the college, under competent guidance and advice.

(*c*) Man's life consists not only in giving, but also in receiving service; an ability to enjoy good and noble things is a check on many a misuse of the compensation received.

(*d*) A man with a broad education is more resourceful in his activity, borrowing and lending his knowledge of laws and his experiences, and utilizing analogies between the various departments of knowledge.

(*e*) The very character of the engineering activity, especially in its higher stages, implies a rather high social standing, and makes it almost indispensable for the engineer to possess at least a moderate amount of general culture.

IV. *Influence of College Training on Man's Usefulness and on His Enjoyment of Life.*—First—The college bred man versus the self-trained man. The curves in Fig. 1 represent the amount of man's usefulness and of his enjoyment of life, plotted to years of his life as abscissæ. Curves 1 and 2 refer to college training, while curve 3 shows the progress of the same man if he should start in a profession without previous systematic training. For some time the self-trained man is ahead of where he would be if he had had college training at the beginning of his career, but soon approaches the asymptote of his limitations, due to a lack of broad and systematic training in fundamental principles. With a college education he may at first lack alertness and ease of application, yet he easily masters any new situation, and gradually rises above subordinate routine.

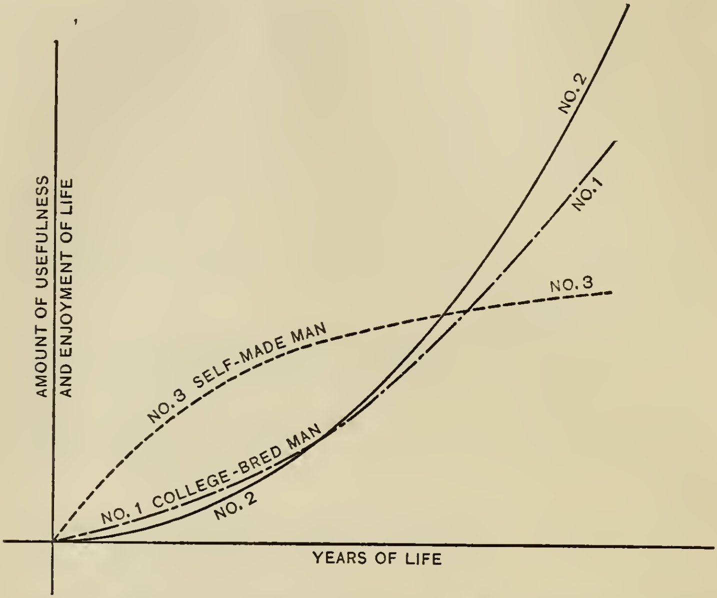


Fig. 1. Influence of College Training on Man's Usefulness and on his Enjoyment of Life.

Second—Curves 1 and 2 compared. Both curves 1 and 2 refer to college education, and both may be said to represent parabolæ of the general form

$$y = ax^n$$

but the values of a and n are different for the two curves, depending on the method of training adopted in college. Curve 1 corresponds to a technical college that gives the student a large amount of practical information, though not so much independent mental training; curve 2 corresponds to a broader university course, in which emphasis is laid upon methods of reasoning and broad underlying principles, rather than upon a large amount of incoherent information. Curve 2 has at the beginning smaller ordinates than curve 1, but afterwards crosses it, and then its ordinates grow faster and faster, since its exponent n is larger than the exponent of the first curve. *"Raise the exponent,"* should be the cry of technical education; it matters not if this should reduce the ordinates in the early part of the curve. A man who is started along a curve with a high exponent is sure to attain in his later years a high degree of usefulness and enjoyment of life.

It is understood that these curves refer to an average man, and to reasonably good schools; poor colleges give curves more nearly approaching the spiral of Archimedes; while the path of a naturally soaring genius cannot be represented at all by a plane curve.

Third—Colleges do not furnish a "finished product." No school can bring out accomplished engineers, nor well educated men, in the sense in which a finished product leaves the factory. Throughout his life, man is in the process of a continuous development, or if he is not watchful, of decay. All that a college can or ought to accomplish is:

(*a*) To start him aright in methods of thinking and doing—the high exponent n, referred to before.

(*b*) To give him a clear notion of the path of his profession and of the possibilities in it.

(*c*) To guide his first steps with encouragement and advice.

B. How to Teach.

I. *The Method of Teaching must Above all be Psychological.*—First—The two purposes of engineering education are: (*a*) to impart certain correlated information; (*b*) to develop logical thinking.

A student is not a bag to be filled with heterogeneous knowledge which he cannot either digest or assimilate. His personality, his reaction on subjects taught, must be kept in mind all the time. This reaction is manifested in the amount of interest shown on his part, and in the measure of his coöperation with the teacher. In short, the method of teaching must be in accord with human nature, must be *psychological.*

Second—Requirements of a psychological method are as follows:*

(*a*) The student must be given time and opportunity to make his choice among several possible professions, or at least among the different branches of engineering. This he ought to do before going into the details of his specialty.

(*b*) After the student has selected a specialty, he ought to be given a general descriptive course in it, in which he is introduced into the various branches of his future work, and is made to understand the necessity for certain auxiliary studies, such as mathematics, physics, chemistry, etc.

---

* While reading the requirements enumerated below, the reader will do well to refer to the table of courses at the end of the article, in order to see the way in which the principles advocated may be incorporated in a schedule of instruction.

(*c*) In the early part of the course auxiliary sciences should not be taught more than necessary for an understanding of the engineering studies; the bulk of mathematics, physics, and chemistry should be relegated to the latter part of the course, where they will furnish a beautiful discipline for the mind, and a powerful tool for advanced work. In other words: *do not sharpen the tools long before there is anything to cut, and first teach the student to use well a few simple tools.*

(*d*) Use theory to explain and to unify observed facts, but do not teach theory before the student has learned enough facts to make their coordination necessary. Otherwise, theory becomes a series of empty vessels of all kinds of whimsical forms, with no substance to fill them.

Third—Some of the objections to the present method of teaching engineering are as follows:

(*a*) The student is given no time or opportunity to select his profession, except on the basis of scattered and unreliable information that he gathered himself. Many a man selects a vocation for which he is not well fitted, and suffers the consequences thereof all his life.

(*b*) The student is not given at the very start a general descriptive course in his specialty, nor is he informed of the place which various auxiliary studies occupy in his curriculum. So he follows his studies on authority and faith, rather than seeing himself their correlation.

(*c*) Mathematics, physics, and chemistry are crowded into the earlier part of the course, it being taken for granted that they are necessary for the understanding of the engineering studies. As a matter of fact, *hardly one tenth of the material studied is used afterwards in engineering;* the rest constitutes dead ballast, which is forgotten by the senior year, just when it ought to be of practical use.

(*d*) Abstract theory of engineering is taught too early in the course, before the actual practice and the ultimate ends of the engineering activity are clear to the student. The result is that the theory remains unconnected with the practical side of the profession, both during the college course and after graduation.

II. *The Concentric Method of Education vs. the Subject Method.*—First—the concentric method. The method of instruction which satisfies psychological and pedagogical requirements may be properly called *the concentric method,* and is represented graphically by a series of concentric circles in Fig. 2; each zone comprising as far as possible the whole scope of a given specialty. The knowledge represented by different zones differs chiefly in the degree of specialization.

During the freshman year (the inner circle) the student is introduced to the whole scope of his profession, though in a very elementary, popular manner. The next year (the second zone) he studies the same subjects from a more special point of view. The third zone represents the same subjects still more advanced, etc. For example, in applying this method to the study of history, the first zone would represent a broad sketch of the destinies of different nations; the next zone would be a more detailed treatment of the most important historical periods; the third zone may include a critical study of original sources and actual remains, and the fourth—the philosophy of history.

Or, in studying the steam engine, the first circle corresponds to a purely descriptive sketch of the operation of the engine, the handling of it, and the troubles connected therewith; the second circle represents a more detailed study of the parts, and an experimental investigation of the accompanying phenomena; the third year would comprise the theory of these phenomena from the standpoint of thermodynamics, mechanics, strength of materials, etc. The outer zone would represent design and special investigations. The dotted circles on the diagram represent advanced post-graduate work and symbolize infinity of knowledge.

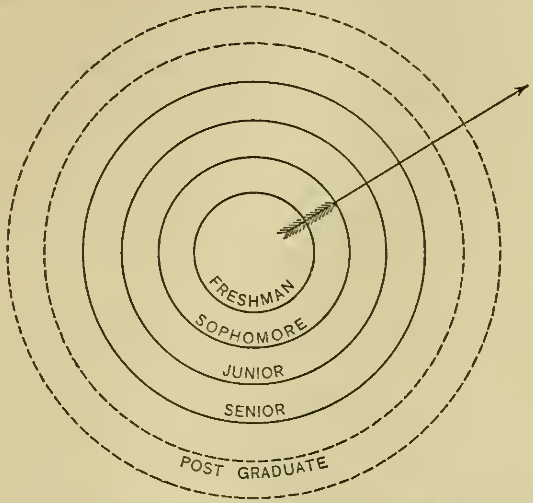


FIG. 2. Concentrically Widening Student's Mental Horizon.

Second—The subject method. In contradistinction to this system, the method now in vogue, or the *subject method* is represented in Fig. 3. Here the student begins his freshman year by studying several subjects of an abstract character, subjects having no obvious relation to one another. They are in part auxiliaries to subsequent studies, in part are supposed to develop logical thinking and imagination. The subjects introduced in the second year are based partly on the studies of the previous year, partly represent a new departure, but again their relation to the principal subject of study is not sufficiently evident to the student, so that he blindly and reluctantly follows the program, instead of actively cooperating with the teachers.

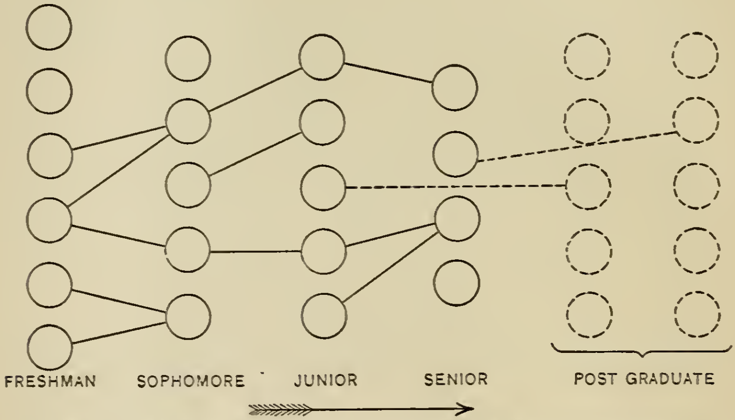


Fig. 3. Lack of System in the Present Way of Instruction (Subject Method).

In the third year begin the professional studies, based on the sciences absorbed during the first two years. But these professional studies are again, as a rule, of too academic a character, too abstract; the whole underlying idea of the present system is that practical applications must follow the general theory. Thus only in his senior year does the student come to the practical side of his profession.

Some of the courses of study in the scheme shown in Fig. 3 are not connected with any subsequent studies, or are connected to advanced problems only (the dotted lines), which hardly one student out of a hundred takes. Nevertheless, all students are required to take these preparatory courses.

It is particularly unfortunate that the student does not realize the necessity for many of his studies during his college years, and that the significance of some of them remains for him an enigma through life.

Third—The correct way of educating engineers is from practice to theory.

(*a*) The concentric arrangements of courses in electrical engineering, shown in the table at the end of the article, is also represented diagrammatically in Fig. 4. The shading is shown growing darker from the freshman to the senior year; this signifies a gradual change from description and practical instruction into theory and analysis. The proportion of the time allotted to the specialty (in this case electrical engineering) is gradually increased, as well as the time devoted to the auxiliary sciences (mathematics, physics, and chemistry). On the other hand, the time for the related specialties (in this case mechanical engineering) and for general culture is gradually reduced. Moreover, all groups of studies are carried throughout the course, so that the stu-

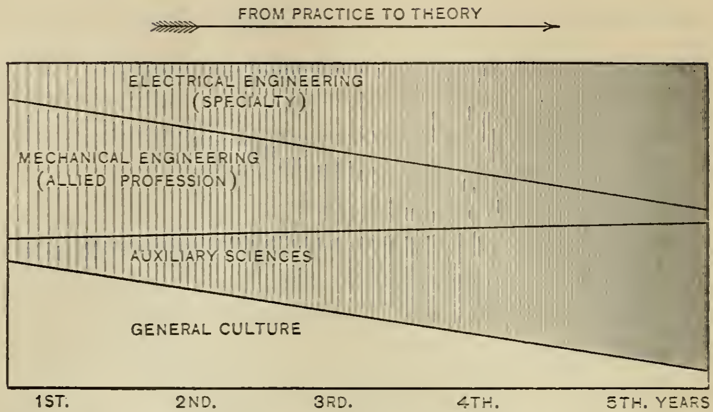


FIG. 4. Arrangement of Subjects of Study According to the Concentric Method (from Practice to Theory).

dent becomes thoroughly familiar with the methods of reasoning in each group, and is not allowed to forget any.

(*b*) In contrast to the above, the general arrangement of courses now in vogue is shown in Fig. 5. The darkest shading here is in the freshman year, and the

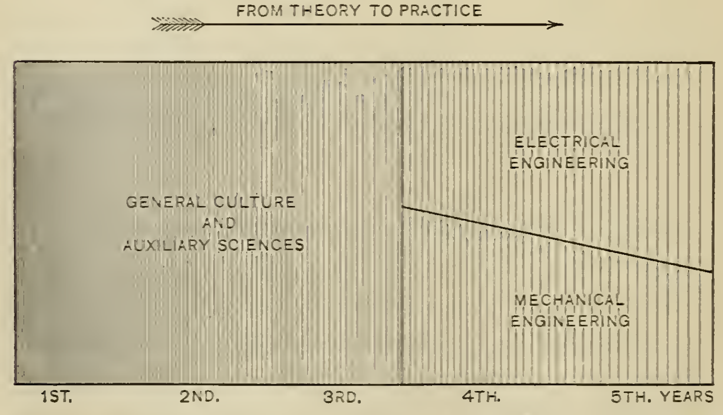


FIG. 5. Arrangement of Subjects of Study According to the Present Method (from Theory to Practice).

general trend is from theory to practice. The first two or three years are filled with detached auxiliary sciences, which are coordinated only in a small measure with the engineering studies, and which for the most part are not used at all. Besides, the student is not taught the engineering courses long enough to assimilate even the fundamental notions thoroughly. Time is important: cramming a subject into one or two years does not help to assimilate it; though the same subject is easily mastered if studied continually throughout four or five years, even though but a moderate amount of time is devoted to it each year.

III. *Some Objections to the Concentric Method Answered.*—First—*Descriptive courses in the freshman and sophomore years are of necessity superficial.* That which seems superficial and of every day occurrence to us, can be made deep, interesting and stimulating enough for the beginner. Moreover, the principal object of these courses is to make clear to the beginner the scope of his future profession and the correlation and significance of various disciplines which he is about to undertake. This adds to the efficiency of instruction and develops student's professional consciousness.

Second—*With the concentric method certain facts and relations have to be repeated two or more times during the course; this involves loss of time.* The author considers repetition one of the advantages of the concentric method, and not open to objection. It is *unpsychological* to learn the principle and the details of a subject at the same time, and then to forget both. We see the results of such procedure with our graduates, who often retain insignificant details and forget the fundamental relations. Wtih the concentric method, the underlying principles are each year refreshed in memory, every time from a more advanced point of view and with new applications. Said the old wisdom *"repetitio est mater studiorum"* (repetition is the mother of studies).

Third—*Engineering cannot be taught properly without a preceding knowledge of mathematics, physics, mechanics and chemistry.* This is true to some extent, and the author emphasizes the importance of these sciences by demanding their study throughout the whole course. He objects only to teaching them long before they are needed, without any connection with the following courses in engineering. The engineering given during the first term of the first year must be mainly based on the high-school knowledge of mathematics and physics; a few additional facts and relations can be given immediately in the engineering courses themselves, in an interesting and connected way, with the applications. The same method may be followed during the first two years, the few necessary mathematical relations and facts of nature being given in the corresponding engineering courses. At the same time special courses, such as "calculus for engineers" are begun, with illustrations from engineering and physics, tending to make the mathematical reasoning clear and useable. Then, beginning with the third year, after the student has learned the fundamental notions of mathematics, mechanics, physics and chemistry in a somewhat disjointed and intuitive, but tangible way, in connection with practical applications, he is ready to generalize and to systematize his knowledge by means of special courses in these subjects. His engineering studies also become more and more theoretical, so that he really needs more and more auxiliary sciences. It becomes then merely a matter of cooperation between the teachers to arrange the courses so that theory precedes the applications by a few weeks or a term.

Fourth—*With the present method a student, not fitted for mathematical reasoning, drops out during the first or second year, while with the concentric method he may manage to drag almost through the whole course and only find his inability during the last year.* To this the author replies that with the present system many an able student, who would have done honor to the profession, is dropped at the beginning of the course, due to his inability to get through abstract mathematics and mechanics. He may be a man of a practical turn of mind, just the kind of man to be valuable in the profession; he might not have had any trouble with the same subjects if they were given later on in the course, in connection with their applications to engineering. On the other hand, a man with a marked analytical faculty, who ought to become a mathematical physicist, and not an engineer, now successfully masters the first two or three years of the course, only to be disappointed in the end when he comes to the practical side of it. With the concentric method such a student would drop the course at the very beginning, having had a glimpse at the practical side of the engineering profession. In short, the advantage of the concentric method is that the student sees the true character of his future activity from the start, and not at the end of the course. With the present method large amounts of mathematics, mechanics, physics and chemistry stand between him and engineering proper. They stand as a horde of ferocious guardian giants of old, whom he has to conquer before he can be united with his beloved princess.

Fifth—*The concentric method takes away the solid mental training and the development of character afforded by hard abstract studies and by the unpleasant drudgery of the present method.* This is not so: the concentric method gives a better opportunity for a strict logical training, because it relegates it to the last two or three years of the course, when the student has not only the form, but also a tangible content for his premises and conclusions. In engineering a certain amount of drudgery, such as drafting, shop work, taking readings in a laboratory, etc., is not to be dispensed with. Teachers, who believe that a large amount of drudgery and routine work affords a good training in character, will always find a sufficient opportunity with any arrangement of courses whatever.

Sixth—*The introduction of the concentric method means such a radical change in schedules, in equipment, and in the character of instruction, that hardly any college with established courses can afford it.* However, the change is not as difficult as may seem at first, considering that only freshman courses need to be changed the first year, only sophomore courses the second year, etc., so that the total rearrangement takes five years. A year in advance of the proposed change one of the professors of electrical engineering is requested to prepare a general descriptive course

INSERT FOLDOUT HERE

in electrical engineering for freshmen, with lantern slides, simple experiments, etc. One of the professors of power engineering is asked to prepare a similar course in prime movers, and so on. Each department easily takes care of its new courses, and with a proper cooperation of all concerned the change is accomplished without difficulty.

Discussion.

Dean Kent: I obtained Professor Karapetoff's paper published some six months or more ago and was so much interested in it that I sent it around to the heads of our departments and asked each one to give his idea of the paper. I received back three or four letters expressing the greatest difference of opinion—one man saw one side of it, and another another side of it; some approved of it in chief and differed in part, and some condemned it almost in the whole, but said there were a few gems of good thought in it. I told them afterwards that I did not want the paper criticized to find fault with it but to find the gems in it.

Professor Karapetoff has outlined a method of thinking in regard to engineering subjects which we must think about in the future. He has expressed a new idea in engineering education and one which we should consider carefully. My own mind has run somewhat in the same direction, and I proposed to our engineering department that we should prepare a course of engineering for freshmen; that we should give talks to the freshmen and give them broad, outline views, pictures, lantern slides, or anything that will be interesting, and that the same be done by all the other engineering courses. I believe that then the students would be able to make a more suitable selection of their courses than they now do.

Professor Woodward: I think our universities are for the whole country, for the whole youth, and it is not anything against a boy that he comes to the university with a limited knowledge of what the world has to offer, or of what engineering is. I am glad to say that we leave the door open to the young man as to what course he should take. I am utterly opposed to an early selection of a course of study; I would like to postpone it at least till the third year of the courses. When a boy has finished his high school course and comes into the university, he does not know what he is good for nor what the thing is that he said he was going to study. He properly leaves the decision open; he leaves the doors open, and, while I cannot wholly endorse the last paper throughout, I believe that the writer of it has a good theory and that he has given many good points.

Professor Karapetoff: The amount of time necessary for instruction is not larger with the method suggested than with the present method of study; I cannot see that a change in the method would make necessary an increase in the number of teachers. I would also add that at the age of seventeen or eighteen you can just as well teach the first-year students cyclopedia of law, and of medicine, so that they would not even be required to take up engineering if they found something else more to their taste. After a year, they can then, if they choose, go on with their medicine or law. This gives the boys a chance to select their profession intelligently.

TWO YEARS OF THE COOPERATIVE ENGINEERING COURSES AT THE UNIVERSITY OF CINCINNATI.

BY HERMAN SCHNEIDER,

Professor of Civil Engineering and Dean of the College of Engineering, University of Cincinnati.

This paper will attempt to set forth briefly a few of the principal features developed during the two years of operation of the cooperative courses at the University of Cincinnati. For the information of those who are not familiar with this system a short statement of it will be given.

The cooperative courses, as now operated, contemplate that a student shall work alternate weeks in a mechanical, chemical, or electrical factory in Cincinnati, and at the College of Engineering of the University of Cincinnati. The class is divided into two sections, which alternate with each other during the collegiate year. During the summer students are employed in the shops full time, but are given a vacation of about three weeks. The course in the shop is carefully planned, and in general the students' work is from the raw material to the finished product sold. They are paid for this shop work on a scale of wages which begins at ten cents per hour and increases at the rate of one cent per hour every six months, making the total earnings of the course about $1,800.

The course is six years long, and is just as thorough, broad and cultural as the regular four-year course and has the same entrance requirements. Applicants for positions in this work are required to enter the shops about the first of July preceding their entrance to the university and must satisfy the shop owners as to their integrity, zeal, stamina and adaptability before they will be accepted by the university in the fall. This, briefly, is the cooperative plan.

When the course was begun two years ago, about thirty manufacturers agreed to make the experiment. At the present time there is only one shop of any size in the city of Cincinnati and vicinity which will not gladly accept these student-apprentices. The plan has worked with the utmost smoothness in all the cooperating shops excepting one. This shop has its main office in another city, and during the two years of the cooperation there have been three changes in the management of the local shop. For this reason the cooperation has not been as frictionless as desired. With this exception, however, manufacturers are entirely satisfied that the system is a thorough success. The course was started at a period of high prosperity and has worked smoothly during the depression. No students have been thrown out of work, even temporarily, but on the contrary the manufacturers are asking us for additional men for next year.

The cooperation of the employers, contrary to many predictions, has been cordial, intelligent and far-sighted. The supremacy of Cincinnati in the manufacture of certain kinds of machinery is not astonishing, in view of the character of the men who have organized and who manage its shops. The writer is of the opinion that a more progressive or broader-minded set of manufacturers can not be found.

When the first year the course was put into operation, about sixty young men came to the university to inquire concerning it. Of these forty-five went into the shops, and when the university opened in the fall twenty-eight were left. The second year there were eight hundred inquiries and applications; from these sixty were selected and sent into the shops, and when the college opened in September forty-four were recommended to us and started their university work. This year the applications and inquiries approximate two thousand; from this number we expect to select less than one hundred men, and, judging from last year's experience, about two thirds of these will begin the course in the fall.

It will be evident that the selection from this large number is one of the most serious and important problems which we have to meet, and the work of selection has opened our eyes to some features of engineering education which we believe will be interesting and instructive to the teaching profession.

Seventy-five per cent. of the applications are from young men who desire to become electrical engineers. As far as possible, every prospective student is personally interviewed, and upon his statement that he desires to become an electrical engineer, he is immediately asked, "Why?" The answers usually indicate that the student has one of two ideas: first, he has read that this is the electrical age and that a man in order to acquire money in the future must be an electrical engineer. His impression is that an electrical engineer is one who does spectacular things.

He has what we have come to call the "dazzle idea"; to use a phrase of the day, his conception seems to be that electrical engineering is a series of bizarre "stunts." As to the hard and tedious problems which confront the electrical engineer, he has absolutely no idea. The second class are those who think that electrical engineering is wiring a house. It is astonishing how many high school graduates have this conception. In the interviews the real object of the electrical engineer's career is pointed out to the young man and he is told what the six years' cooperative course means in hard and laborious shop work. Many of the applicants, of course, withdraw when they learn that electrical engineering is not a pyrotechnic display, or when they are told that they can learn how to wire a house in six weeks at a night school. A considerable number also surrender to mental cowardice in the matter of dirty work, long hours, and shop discipline. If we can get one good man, sound mentally, sound physically and temperamentally adapted to the profession, out of twenty-five applicants, we consider that we are doing fairly well.

Yet this is the material which enters our engineering schools, with the same distorted ideas; and so far as the writer knows, our colleges do not tell them what electrical engineering really means. I venture the assertion that if a thorough canvass were made of freshman electrical engineers, throughout the country, the majority of them would be found to have the "dazzle idea."

In mechanical engineering applicants seem to have a better grasp of what the words mean, and we get one good man in about ten. In chemical engineering the same fairly good knowledge of the intent of the course is shown.

In selecting a student the question in the mind of the writer has always been: "Is this young man before me the kind of a man on whom the university should spend about $1,600?" This brings up, as you will see, the whole problem of the economics of engineering education. The scope of this paper will not permit as thorough a discussion of this subject as should be given it, but the essential ideas may be outlined. It costs any self-respecting institution about $2,000 for every student it graduates. The student pays to the school from $200 to $1,000 for his instruction. The school, therefore, expends on the student anywhere from $1,000 to $1,800. This money is obtained either from endowments or from taxes. In either case it is a public trust, held by the trustees of the school, to be used by the faculty for the benefit of the public through the education of young men. If we are going to spend from $1,000 to $1,800 on every graduate, is it not a reasonable business proposition to select the men on whom the money is to be expended?

The criterion which we have adopted may be stated as follows: Only that man should receive a higher education who would in all probability be successful without it; and this is really the basis of our selection as far as human judgment and careful observation can make it. There is nothing more helpless and hopeless than the educated "mollycoddle," and there is nothing in all our educational system so wasteful as the present scheme whereby any young man who has the money, and enough brains merely to get through certain mental work, is given training, which is denied to a young man of much superior general ability, because of a lack of funds. Parenthetically it may be stated here that a large proportion of the failures in the course have been city-bred boys; country boys as a rule "make good." As a matter of fact, some of our largest concerns will not accept city-bred boys in the future.

There is no additional expense in the cooperative system by reason of the alternation except in the lecture courses, for all classes must be subdivided into sections of about twenty men each, and it does not matter whether the first section is taught this week and the second next, or whether the first is taught at 10:30 and the second at 11:30 o'clock on the same day. The lectures, of course, must be repeated, but the preparation for the lecture is the same.

There is, however, a large measure of economy in the cooperative course by reason of the fact that the university is not required to equip, maintain and supervise practice shops. The manufacturing shops of Cincinnati are the practice shops of the university, and the student, instead of paying us for instruction, receives much superior training in the factories and is paid for his work. Engineering laboratories can be cut down in equipment to a certain extent without any loss in efficiency, for the testing-rooms and engine-rooms of the commercial shops become in a measure our engineering laboratories.

Let me summarize in a condensed form a statement of the additional expense under the cooperative system, as compared with the reduction under that system:

REDUCTION OF EXPENSES UNDER THE COOPERATIVE SYSTEM.

1. The equipment and maintenance of shops including instruction. This reduction in cost can be computed.

2. A cooperative student attends the university one half time for six years, or full time for three years. In *time*, therefore, there is a saving of one year over the four-year course. This reduction can only be estimated, and is partly included in 1.

3. The cooperative course has students who are in dead earnest. Further, they have practical experience. As a result they get much more out of the same amount of theory than the four-year students do. In other words, the efficiency of the instruction per hour is increased. This factor can be only roughly determined.

4. In the cooperative course the weaker brother is eliminated before he enters college. In the four-year course he is eliminated during the first, second, and third years. In the former case the raw material is carefully selected. In the latter, little attention is given to the raw material except as defects show in the making of the product—that is, after expensive work has been done on it. This reduction in "factory losses" can be determined but roughly at the present time.

ADDITIONAL EXPENSE UNDER THE COOPERATIVE SYSTEM.

1. All lecture courses must be given twice. (Note that the *preparation* is the same for the two lectures as for the one lecture, since each lecture is merely repeated.) This increase in cost can be computed.

It is hard to make an accurate determination of the relative efficiency of instruction in the four-year and the cooperative courses. The records in one or two subjects, however, will indicate about what this would be. In calculus, for instance, not one of the cooperative students failed. The lowest grade received by any cooperative student was 73 per cent. (60 being the passing grade and 100 the maximum), and one half of the class received over 90 per cent. In the regular four-year engineering course, on the contrary, about twenty per cent. of our students failed in calculus and few received a grade above 90 per cent. In this connection the fact should be noted that the examination given to cooperative students was harder than that given to regular students. In chemistry the cooperative students and the regular students have the same examination, answering exactly the same questions. Ninety per cent. of the cooperative students passed; and about eighty per cent. of the regular students did so. This need not be astonishing, for, with but few exceptions, the cooperative course is not carrying any dead wood. It will be seen, therefore, that since the efficiency of the instructor depends primarily upon the amount of actual substance absorbed by the class, it is increased very considerably in the cooperative courses.

When this system was started two years ago many questions of detail arose. For instance, the matter of the rearrangement of the college courses was taken up. It was concluded, however, that the best thing for us to do would be to learn by experience. The university publishes curricula, but it must be definitely understood that these are not exclusive and inflexible. As a matter of fact, they have been changed radically, and since the last publication of them they have undergone further changes. They will continue to be modified for years, for happily we are being driven from traditional methods by the cooperative students themselves. Here is a sample of what happens:

The instructor in mathematics covers the blackboard with the demonstration of a long formula, and when he has finished it he turns to the class and asks, "Do you understand that?" The class replies that it does, but inquires seriously, "What shall we do with it?" This has happened a number of times, and at first caused much annoyance to the instructor; but when it was pointed out to him that if a thing had no use it was useless and should not be taught in an engineering college, light dawned on him, and he now spends much of his time hunting practical exemplifications of theory. This is the characteristic attitude of the cooperative student, which is not surprising. Our four-year students are accustomed to being handed a formula which they hold until examination time, when they hand it back. The cooperative student in the shop is handed a tool and is instructed how to use it. He uses it, hands it back to the tool-room, and thereafter knows where to find the tool and how to use it. When he is handed a formula or a theory at the university it is a matter of second nature to him to expect to be shown how to use that formula or theory prior to his handing it back. Thereafter, as with the tool, he knows where to find it and how to use it.

We have inaugurated what we call the "reverse quiz" in class. Toward the end of the hour students are given permission to ask any questions that have a bearing upon the subject, and this has been perhaps the most valuable addition to our system. It is, of course, uncomfortable for a young instructor, but if he is the kind of teacher our engineering college ought to have, he will work to meet the situation. If he is not, there is only one thing for him to do. The shop knowledge of the student has demonstrated to us the fact that some of the instruction in our colleges is not only frequently out of date, but also that it is as often absolutely wrong. You will observe that there is a check upon the instructor's work which can not be had in any other way except through this practical knowledge of the student.

The questions of these young men have caused us to change our courses and will cause many more changes as the work advances. Mathematics, for instance, is taught as one subject, the fundamental principles of university algebra, trigonometry, analytical geometry, and calculus being given during the first part of the freshman year; and thereafter any one formula is derived by the different methods. The course in mechanics is taught as part of the course in calculus. Descriptive geometry and machine drawing will hereafter be given as one subject, because when a student was formerly given a problem in descriptive geometry he wanted to know its application, and when told the application, wanted to know whether he could not put it at once on the same sheet.

It will be seen, therefore, that while we simply took the four-year course at the beginning and spread it over a period of six years, we are changing it considerably, by reason of the experiences which we have in every-day class work.

It has become evident also that it will be necessary to bring some of the engineering work down into the earlier years. As a counterbalance to the essentially practical attitude of the student we have inaugurated a broadening course in the social, economic, industrial and political development of the human race, together with courses in biology and geology. It was originally intended that this course should cover a period of three years, but we are now inclined to give it through the entire six years.

The alternating periods were fixed at one week tentatively, and this has proven very satisfactory. A vote of the students was recently taken, and they were unanimously in favor of the one-week period as giving them the proper alternation of mental and physical work. They also state that absence from the shop for more than a week allows their muscles to become soft, and for this reason they prefer to continue on the week system. The shops also desire to keep this period of one week, because if the period were made longer at the university the student would lose some of his skill by the time he returned to the shop. It has been definitely concluded, however, that when the young men go into the designing and sales offices—which will be about the fifth year—the alternation will be by semesters. It will be impossible for a young man to work in a designing or sales office with any benefit to himself or to the firm for a shorter period than six months. The students in the cooperative course will then enter the regular classes at the university, when a better comparison of the work of the two classes of men can be made.

Since the cooperative student is at the university for a period of three years, as compared with four years of the regular student, it became evident, of course, that he would be required to do more actual class and laboratory work per week than our regular students. Additional hours were given to him during his alternate week at the university, and the roster was considered by some of our faculty to be too heavy. At the end of the first year, however, the students finished without any seeming effort and with much better records than did our regular students.

This year a further experiment was tried by the writer on the freshman cooperative class by giving them work every period of the day from 8:30 until 5:00 oclock, with one half hour for lunch, except on Saturday morning, when they work from 8:30 until 10:30 o'clock. This, it will be seen, is about the heaviest roster the student can possibly carry. At the end of the year the men were more vigorous, mentally and physically, than they were in September. They were more active in university social affairs, athletics and general student life than the regular students, and they had made much better scholastic records. This seems to be a demonstration of the statement that "if you want a thing done, ask the busy man to do it." It is the writer's personal opinion that this class of men could finish all the work that our four-year students have, in a five-year cooperative course; but we shall continue to have a six-year course and shall simply put in such additional subjects as these students are peculiarly equipped to take and which our regular four-year students can not take by reason of a lack of practical knowledge.

The fundamental principle underlying this course is based upon the rational assumption that the proper way and the only way for a young man to learn the practical side of his profession, together with business details and an intimate knowledge of the labor problem, is by working as a regular employee in a commercial shop; and, further, that the only place where he can learn properly the scientific and the cultural subjects is at a school under trained teachers. This further implies that the school work and the practical work should, as far as possible, go hand in hand, so that the young man may step from school to business just as readily as he does from one promotion to another in after life. The periods of alternation, the course through the shop, the wage scale, etc., are details dependent upon local conditions entirely. The writer believes this principle to be all-important and to apply to all engineering and industrial education.

At the University of Cincinnati there is no cooperative course in civil engineering, because the local conditions will not permit it. There could be one, for instance, at Pittsburg, in connection with the American Bridge Company and the railroad lines centering in that city. The Pittsburg school could also have cooperative courses in mechanical, electrical, and metallurgical engineering. At Philadelphia there could be courses in marine engineering and naval architecture as well as in mechanical engineering. The plan contemplates that the school shall have cooperative courses in all those departments which have a sufficient number of industries to make the operation of such a course possible. The details will be matters of compromise, as they are with us at the present time. An eastern enginering school about to install this system with a large manufacturing plant in its vicinity contemplates having a two or three-week alternation system, with gradually increasing periods to graduation, the last year of the course to be spent in school. As stated above, this is all detail and simply a matter of local conditions and compromise. Different professors, for instance, will disagree as to what should be given to these students at the university, but all courses, as a matter of fact, whether four-year or cooperative, are a matter of compromise. Since the system is new, there necessarily will be many changes in the next few years. Particular emphasis is placed upon this fact because of criticisms which have been made condemning the whole course on account of some immaterial detail.

In conclusion, permit me to call your attention to the fact that educational methods are traditional. Oxford and Cambridge were an outgrowth of the old monastic system of withdrawing young men from the world for religious contemplation and literary pursuits. Yale, Harvard and Princeton were patterned after Oxford and Cambridge, and every engineering college of today is an offshoot of a school founded upon this old academic idea; consequently we have the absurd system today which withdraws young men from all contact with the world's work to prepare them for that work.

Every scholastically trained man at first objects to this cooperative system, for the simple reason that it is not the way in which he was trained. It is astonishing to find how hard it has been to overcome this bias of tradition. College graduates have a peculiar reverence for the customs and forms of their college days, simply because they were in the college environment at the impressionable age; consequently any plan which tends to change radically the way things were done when they were in college meets with an opposition which is based on sentiment rather than on logic.

But putting aside for the time being the question of the ultimate destiny of the cooperative system of education, I want to ask and have you answer for yourselves frankly this question:

If the men who occupy the engineering chairs in, say, the three best engineering institutions of this country were to meet with the chief engineers and the general superintendents of the three largest electrical companies of the United States to plan for the instruction of young men in the professions of electrical and mechanical engineering, and if they did not permit themselves to be hampered by the precedents of the old academic system and biased by the methods of their own scholastic preparations, do you suppose they would devise the present four-year system? Would they not, with their knowledge of the requirements which an engineer should fulfill, plan a course which did not teach largely from books? Would they not give a young man in his formative years that broader education of life which breeds determination from the doing of disagreeable tasks; which builds a physical constitution to help stand the mental stress of the future; which moulds a spirit of broad toleration by daily contact with the inflexible limitations of man as the Creator has made him; which stirs initiative to accomplishment by ability to do as well as to think; and which bases the value of money upon work efficiently done, rather than upon the pleasure it can buy?

Would they so plan that the engineer would have the narrow one-sided view-point obtained wholly from books, rather than the clear judgment derived from experience properly supplemented by instruction? Would they devise a course almost entirely given to analytical investigation, or would they incorporate a goodly portion of constructive action? Would they not plan a foundation more in accordance with the specifications which that great philosopher Huxley stated in his definition of a liberal education? "That man, I think," said Huxley, "has had a liberal education whose body has been so trained in youth that it is the ready servant of his will, and does with ease and pleasure all that, as a mechanism, it is capable of; whose intellect is a clear, cold logic engine, with all its parts of equal strength and in smooth running order, ready, like a steam engine, to be turned to any kind of work and to spin the gossamers as well as forge the anchors of the mind; whose mind is stored with the knowledge of the great fundamental truths of nature and of the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions have been trained to come to heel by a vigorous will, the servant of a tender conscience; one who has learned to love all beauty, whether of nature or of art, to hate all vileness and to esteem others as himself."

Discussion.

Professor Woodward: I would like to ask Professor Schneider what sort of electrical and mechanical companies are included in those thirty companies which he mentions in Cincinnati which take pairs of students the first year. Also, do the companies which take students, agree to give them what you might call a "course" of practical study? Is that "course" approved by the university authorities?

PROFESSOR SCHNEIDER: I stated that thirty manufacturers agreed to cooperate. I did not send boys to all these plants. Some of the companies were: The Bell Telephone Co., Cincinnati Milling Machine Co., Cincinnati Planer Co., Bullock Electric Co., Lodge & Shipley Co., Cincinnati Machine Tool Co., Cincinnati Tool Co., and so on.

In mechanical engineering, some of the shops cannot give a full course, on account of having no foundry; in such a case, the young men are sent from these shops to other shops where there are foundries.

When a shop is given apprentices, there is a contract which is signed by the firm, the boy and the university. The first clause in the contract has a blank space, which is filled out with the entire shop work that the young man is going to get in six years; the university will not sign until that statement of his work is satisfactory.

PROFESSOR WOODWARD: I am deeply interested in this matter, partly from a general interest in such an effort, and partly because Washington University, being in a great city, has been stirred up by the Metal Trades Association to investigate the whole subject; and I am the representative of the university to get information. When I get back I shall have a meeting immediately with the Metal Trades Association committee to talk over the whole plan and see what we can do in the city of St. Louis, because it is hoped that we can interest an entirely new set of students, a set that otherwise we can not get at all. We have room enough in our laboratories and in our lecture rooms without duplicating any of them; because every one of them is idle a part of the time at present; we only need to furnish additional teachers. I would like to ask one more question. In starting out did you have any difficulty in arranging the hours of recitation and drawing, and in getting the additional instruction?

You stated that the sections at the university begin their work at half-past eight, and that with half an hour for lunch at mid-day, they work on to about five o'clock, and yet that they take the lead in college activities, athletics, etc. When can they find time to get their practice?

Professor Schneider: In answer to the first question of Professor Woodward, I would say that we had no difficulty at all. Our four-year course is mapped out regularly, and we have now mapped out a six-year cooperative course; there is no confusion.

In answer to his second question, I would say that we do not allow the cooperative students to play on the university foot-ball team, but suggested that they have a foot-ball team of their own.

Dean Jackson: I would like to ask a question or two. The college with which I am connected has been having certain conferences with a large railroad corporation in regard to similar courses, but we are situated directly between Philadelphia and Pittsburg. Mr. Fred Taylor, an ex-president of the American Society of Mechanical Engineers, has suggested that possibly good results can be accomplished by sending a man to the shop at the end of the freshman year and leaving him there for a full year, and that after that year the same thing might be done during the vacations of the remainder of the college course. This does not connect the college so intimately with the industries as does Professor Schneider's plan, but it seems to me to give the boy a good practical appreciation of what he is going to do in after-life, and develop in him a proper professional spirit. I should like an expression of the opinion of the society upon the proposal of Mr. Taylor, and also as to whether his system is not especially available for colleges at a distance from cities. It strikes me that Professor Schneider's method eliminates too large a number of students. We have got to educate not only those who can pursue Professor Schneider's course, but must include larger numbers if we are going to prepare enough superintendents, managers, etc., to carry on the industries of this country. I am a firm believer in Professor Schneider's ideals; I think he deserves the hearty thanks of all of us. The movement, it may be of interest to recall, is merely the repeating of history, in a way, because after the French Revolution the newly organized industrial establishments of France had intimately connected with them efficient industrial schools for specialists. These schools advanced France more quickly to the front than any other cause, and if she had continued to improve her efficient system, I presume that Germany would not have been able to gain upon her industrially, as has been the case during the past few years.

Professor Schneider: In answer to Professor Jackson I would cite a case in point: We are about to cooperate with the town of Dayton, which is about fifty-six miles away from us. That cooperative system with Dayton came about through some young fellows in Dayton who wanted to enter this course but did not have money enough to come down and stay in Cincinnati all the time. They devised a system whereby "A" would be in Cincinnati one week occupying a room, and "B" would be down the next week occupying the same room while "A" would go home and work. That system might be developed in some other institutions. However, if the shops are sixty miles away from the university, the periods of alternation would have to be longer. The plan which you propose, of having the boy work a year in the shops at the end of his freshman year and then every summer thereafter, is an advance on the old method, but I think that if you plan for more intimate cooperation you can get more out of the shop work.

Professor Cooley: I have been very much interested in Professor Schneider's paper. I have known about this work for some time and am very glad he has presented such a paper to us. In developing the good features of this course in Cincinnati he makes rather a sweeping condemnation of the so-called "old style" courses. I would like to ask whether the success which has attended Professor Schneider's efforts in Cincinnati is not largely an outgrowth of our modern industrial conditions, and also whether such a course as he has developed would have been possible say fifteen to twenty-five years ago, taking into consideration the industrial conditions, the attitude of the trade unions and of the manufacturer; in other words, is not the situation in Cincinnati to-day directly the outgrowth of our modern industrial conditions, and is it fair to condemn all of the old systems which have led up to and made this one possible?

Professor Schneider: I did not intend to condemn the four year courses at all, but I do think that they are utterly inadequate for the present situation. If you consider the large number of very able men who are the product of the four-year system, it seems absurd to condemn it. I think education, as everything else, is a growth. The industrial situation has changed rapidly in the last few years; and I do not think the cooperative course would have been possible twenty-five years ago.

Dean Kent: It seems to me that this plan of Professor Schneider's is an illustration of what is happening along all educational lines. Some hundred years ago education was for the few, and then afterwards for a few more. In the beginning of engineering education in this country, the engineering schools educated a few men for the higher positions, but Mr. Schneider's attempt is to educate more men for the lower positions and give these men the kind of education that they need. None of the schools have hitherto led in this direction. It is remarkable to see how few technical men are found in our machine shops. This is a new step forward in education, to educate men for the positions that the old schools did not educate for. It has not been, as I understand it, a means of making any better engineers than before, but is a step forward in educating more men than ever before. It is giving an opportunity for men to get an education that would not have been possible for them otherwise. The problem is, not how we can educate better engineers than before, but how we can educate a larger part of the population of the country than ever before. The real question is not one that relates to our universities, but it is one of the industrial education of the common people.

Professor Williston: Professor Jackson called attention a moment ago to a point that I think is brought out very clearly in Professor Schneider's paper—that it is the cream of a very large number of men who make application for this course who are admitted into the six-year cooperative plan; and that the reason for the remakable successes in intellectual as well as in practical work is partially because only the best men are chosen. There is, as I understand it, a very careful selection. Only those who give evidence of possessing a reasonable probability of developing leadership in the future to a very high degree are accepted; for the aim is, Professor Schneider will correct me if I am wrong, to train a very high grade of mechanical engineer especially well adapted to meet the difficult and advancing problems of modern and industrial engineering.

Professor Jackson referred to the fact that other institutions had some "skimmed cream" as well as some cream. I believe that this is absolutely true, and that one of the great advantages of the cooperative plan is that it gives better opportunities to select for the courses only such men as have special aptitude for the kind of professional work to which the course naturally leads.

Professor Kent stated that one of the serious problems in education at the present time is to provide means by which a large proportion of the population may be educated for the practical work of life. There has been before this Society a great deal of discussion regarding the lengthening of our courses and the establishment of post-graduate courses; and the arguments in favor of both of these plans are convincing evidence of the very great desirability of increasing the amount of technical training for those who wish to enter the engineering profession. On the other hand, a great difficulty with such a plan—in many places an insuperable difficulty—is the fact that comparatively few young men have either the financial means or the time at their disposal which they may properly spend for such a purpose, no matter how much they may wish to. Conditions over which they have no control make it necessary for them to get started in their life-work, and to commence to be self-supporting before they reach a given age. Therefore, another very great advantage of the cooperative plan is that it enables many young men of marked ability to whom a college course might otherwise be an impossibility, to obtain a thorough technical training, and also that it enables others to carry their training as far as may be desirable. The cooperative students are self-supporting, and are not, therefore, prevented by financial considerations from getting as much technical training as they desire.

There is another economic question that Professor Schneider has called attention to. It is, I believe, one of the most vital points in his paper. Very few institutions in the past have been seriously considering the question of whether they ought to spend $1,000, or $2,000, or perhaps $4,000 on any given individual; the theory has been, as a rule, that any man who could pass a certain entrance examination had a right to demand the $1,000, or $2,000, or whatever sum the tuition may cost, of the institution. As the trustees of trust funds, I believe that it is the duty of every college or university to satisfy itself very definitely that the individual on whom it is about to spend such a sum of money, is one who will be able to make efficient use of the help received.

Professor Leete: Pittsburg offers exceptional opportunities as a field for technical and industrial education, as Professor Schenider has stated. I hesitate to say anything in regard to the work which is being done at Carnegie, for the reason that we are, as yet, in the experimental stage. I do not want you to think, however, that we have not recognized the possibilities there, or that we have not endeavored to meet them.

We have endeavored to get into as intimate relations as possible with the different engineering industries, but we have hesitated in adopting the plan of Professor Schneider in the School of Applied Science for three reasons:

1. We do not believe that it is practicable to maintain this triple relation between the student, employer and university for so long a period as six years. A failure of the student to meet the requirements of either the shops or the university makes impossible the completion of his course.

2. We have hesitated, also, because we do not sympathize wholly with the relation in which it would place us with respect to the different industries. We do not wish to prepare men for a given concern and to lay ourselves open to the dictation which it seems to us would naturally result from such a course. Professor Schneider has mentioned one instance where students were enabled to bring special pressure to bear upon him to force a result which was not to the best interests of the university. Is it not possible that the relations between the industry and the university may become strained and impossible?

3. We have not adopted a cooperative scheme in the School of Applied Science because we believe that so much time as this plan provides for shop work is neither necessary nor advisable for an engineering training.

I would add, in reference to the last point, that in our industrial college we have succeeded in getting into close relations with the different shops in Pittsburg, following a plan somewhat similar to that of Professor Schneider's. About thirty young men last year who were working in the shops were sent us by the industries for instruction in the trades. The instruction included mathematics, English, the elements of physics and chemistry, and mechanical drawing, in addition to the training in the shops. We took them for seven months in the year with the understanding that they were to return to their shops during the remaining five months and in some instances they were also to work every Saturday. It seems to us that it is in trade education that the cooperative scheme finds its legitimate value.

PROFESSOR SCHNEIDER: It is feasible to maintain the triple relation and to go on indefinitely. There seems to be an erroneous idea among educators that manufacturers are not very broad-minded men.

The idea is a good one for the manufacturer. The students are commercially profitable to him, otherwise he would not put them in the shop. Furthermore, many of the young men graduating from our school will become superintendents in the shops of Cincinnati. I think the relationship will be very safe in their hands.

In regard to the second question, as to the relations that might possibly arise. Some of our faculty were very much afraid of that when we started, but they are not afraid of it now, as it brings good will to the university.

In regard to the third question, the disproportion of time. This course contemplates that a man starts in his business career when he starts at the university. Our statistics show that over 90 per cent. of the mechanical and electrical engineering graduates go into industrial engineering. We are training for that 90 per cent. We place great stress upon the fact that these young men will learn the labor situation, which they cannot learn in the university. I believe they will get broadened from meeting all sorts and conditions of men from the man with the wheelbarrow up to the general manager; that is worth more than the 10,500 hours that they work in the shop. All the matters of technical detail which cannot be obtained in college they will get by close contact with real business.

We had experience with labor unions in one case.

At the time this course was started a strike was contemplated in the Bullock Foundry. When we put our young men in, the union men thought they were strikebreakers, and treated them accordingly. However, the students stuck to it; when college opened half of the apprentices came to the university and the next week they went back to the shops and the other half came, the molders said: "Where were you last week?"

They answered, "At the university."

"Where are the other fellows now?"

"They are at the university."

The molders said to them, "What is this game anyway?"

When it was explained to them they answered, "If you fellows are working in this way to get an education we will not bother you." At the present time the attitude of the workingmen in the shops toward these students is very cordial, indeed, and they will answer any questions that the students ask.

Professor Woodward: I want to make one more remark and ask one more question. My remark is that this scheme is not intended to interfere with our four-year work, as I understand it. It is not a condemnation of our four-year plan; it is not intended to reflect upon it; it is simply a method which seems necessary to meet new conditions for a new set of students.

My question is: Do the subjects taught and studied make it possible for the student to go from one course to the other? I can understand that so far as the boy and the university are concerned, it is perfectly easy for him to go from the six-year plan into the four-year plan, for he will fit in with the work; but what does the employer think of it? Finally, is it possible for him to go from the four-year plan into the six-year plan?

PROFESSOR SCHNEIDER: No students of the six-year cooperative system have gone into the four-year system, except two who were dismissed by me from work in the shops for reasons of discipline. No student desires to go into the four-year course from the six-year course. By a recent decision, it is not possible for any student to enter the cooperative course unless he wants to take the full six years. Many students from other colleges wrote to us and wanted to take the latter half of the cooperative course and we decided not to take any one in this system except for the whole six years.

PROFESSOR MAGRUDER: The trouble with our engineering colleges of today is that we are training the few rather than the majority who desire to go into any line of work. I am glad that the University of Cincinnati, being a municipal institution, has the privilege of training for industrial engineering and industrial life.

CAREERS OF GRADUATES IN MECHANICAL ENGINEERING.

BY F. DeR. FURMAN,

Professor of Kinematics and Machine Design,
Stevens Institute of Technology.

The purpose of this paper is to show:

First. The measure of success of graduates in mechanical engineering, based on the records of *all* the graduates of the Stevens Institute of Technology.

The conclusions under this heading are briefly: that the graduates rise rapidly to positions of responsibility, over 90 per cent. having established themselves after fifteen years, and 98 per cent. after thirty years, in offices requiring a strong intellectual development. The offices and positions here referred to are enumerated in items 1 to 30 of Table I. See also Curve A, Fig. 1.

Second. The nature of their work so far as the application of their technical education is concerned.

It is here shown that about 40 per cent. settle into executive or managerial positions, nearly all in engineering or commercial manufacturing lines; 37 per cent. into broad technical positions such as would be represented, for example, by consulting engineers, professors, etc.; 11 per cent. into positions calling for technical detail; 10 per cent. into the retired list, and 2 per cent. into the class whose whereabouts and occupations are unknown. (See Fig. 2.)

Third. The lines of work and the concerns in which the graduates are engaged, showing also the percentages connected with the several large corporations or so-called "trusts."

The tabulation here indicates that about 20 per cent. of the graduates are engaged in the manufacture of machinery and instruments; 10 per cent. in general manufacturing work; 10 per cent. in general engineering work; 10 per cent. in gas or electric-lighting work, and the remainder in miscellaneous lines. About 20 per cent. of the graduates are in the employ of the large corporations or "trusts." (See Tables V. and VI.)

Fourth. The range of application of a mechanical engineering education, enumerating the specialties of the graduates.

In this connection it is found that the broad course in technical education given at Stevens for the degree of mechanical engineer has enabled a large number of graduates to become successful, and a fair number even prominent, in architectural, civil, electrical, gas, heating and ventilating, hydraulic, marine, mining, railway and structural engineering lines.

The wide range of specialties, in the production of which the graduates of mechanical engineering are concerned, is shown by the fact that less than three men on the average are engaged in the production of the same article or commodity. (See Table VII.)

Every graduate of Stevens Institute has been included in making up the records on which the above briefly stated facts are based.

Items 1 and 2 above have been plotted in Figs. 1

and 2, from the data given in Table I. Items 3 and 4 have been separately compiled, No. 3 from the last catalogue of Stevens Institute of Technology, and No. 4 from a "Directory of the Alumni of Stevens Institute," prepared by Professor W. H. Bristol two years ago.

Stevens Institute of Technology was established in 1871, graduated its first class, consisting of one man, in 1873, and has graduated altogether 1,394 men, the last class of 1908 containing 94, and the average being 40 men to each class. The number graduated in each year is shown in Table IV. and Fig. 3.

Table I. shows the total number and the percentage of graduates holding the various positions or offices common to the engineering and manufacturing world, immediately after graduation, and at the end of 5, 10, 15, 20, 25, 30 and 35-year periods. As will be noted from the table, 1,039 men have been graduated five years or more. Of these, 30 died during the first five years, leaving 1,009 who have reached the end of their first five-year period. Seven hundred and fifty-four men have passed through their second five-year period, 485 the third period, and so on. These are the numbers on which the averages are based.

The "Morton Memorial Volume," issued at Stevens Institute in 1905 as a memorial to the late Henry Morton, first president of Stevens Institute of Technology, was used in making up the body of Table I. This volume contains a record of the successive positions held by each man from the time of his graduation, the photographs of nearly two-thirds of all the graduates, and in many cases brief genealogical statements.

TABLE 1.

Identifying Numbers.	Positions.	Group Letters for Fig. 2	Total Number and Percentage of Graduates Holding Positions Mentioned.															
			Immediately after graduation. Total number that have been graduated 5 yrs. or more, 1,039.		Years after Graduation—Total Number of Graduates Living.													
					5 years. 1,009		10 years. 754		15 years. 485		20 years. 282		25 years. 115		30 years. 52		35 years. 1	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	Consulting engineer.....	G	1	.1	11	1.1	39	5.1	43	8.9	41	14.6	16	14.7	9	17.3		
2	Contracting engineer....	F			5	.5	7	.9	4	.8	4	1.4						
3	Conslt'g & contract. eng.	G			5	.5	3	.4	2	.4	3	1.1						
4	Firm member.............	F	6	.6	56	5.5	64	8.5	44	9.1	27	9.7	8	7.0	1	1.9		
5	Owner of business.......	F	3	.3	7	.7	16	2.1	13	2.7	8	2.8	4	3.4	3	5.7		
6	Patent lawyer............	G			11	1.1	9	1.2	7	1.4	6	2.1	3	2.6	2	3.8		
7	President..................	F			6	.6	13	1.7	23	5.0	22	7.8	15	13.0	5	9.7		
8	Secretary..................	F	1	.1	6	.6	13	1.7	5	1.0								
9	Secretary and Treasurer	F	1	.1	7	.7	7	.9	3	.6	3	1.1						
10	Treasurer..................	F			5	.5	4	.5	4	.8	2	.7						
11	Vice-president.......	F	1	.1	8	.8	16	2.1	20	4.2	15	5.5	1	.8	1	1.9		
12	Architect..................	G					1	.2	2	.4	1	.3						
13	Artist........................	F					1	.2	1	.2	1	.3	1	.8	1	1.9		
14	Chemist.....................	G	1	.1	1	.1	2	.3	1	.2	1	.3	1	.8				
15	Lawyer........	F			7	.7	10	1.3	7	1.4	5	1.8	3	2.6	3	5.8		
16	Private interests.........	F	3	.3	3	.3	5	.7	3	.6	3	1.1	1	.8	1	1.9		
17	Retired.....................	I					4	.5	9	1.9	12	4.2	9	7.9	5	9.7	1	100.0
18	Editor.......	G			5	.5	4	.5	6	1.2	6	2.1	1	.8				
19	Professor..................	G	1	.1	13	1.3	28	3.7	22	4.5	19	6.7	13	11.3	6	11.7		
20	Chief engineer...........	G	1	.1	28	2.7	57	7.6	48	9.9	22	7.9	9	7.9	2	3.8		
21	Manager.........	F			27	2.6	56	7.4	37	7.8	17	6.0	8	7.0	4	7.7		
22	Superintendent..........	H	3	.3	53	5.2	69	9.1	37	7.8	17	6.0	11	9.5	4	7.7		
23	Sales engineer...........	F			16	1.6	18	2.4	10	2.0	3	1.1	1	.8	1	1.9		

TABLE I. —*Continued.*

Identifying Numbers.	Positions.	Group Letters for Fig. 2.	Total Number and Percentage of Graduates Holding Positions Mentioned.															
			Immediately after graduation. Total number that have been graduated 5 yrs. or more, 1,039.		Years after Graduation — Total Number of Graduates Living.													
					5 years. 1,009		10 years. 754		15 years. 485		20 years. 282		25 years. 115		30 years. 52		35 years. 1	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
24	Manufacturer's agent...	F	1	.1	8	.8	8	1.1	8	1.6	3	1.1	1	.8				
25	Insurance manager......	F			2	.2	10	1.3	8	1.6								
26	Chief draughtsman	H			43	4.2	16	2.1	7	1.4	3	1.1	1	.8	1	1.9		
27	Department engineer...	H	4	.4	96	9.5	84	11.1	35	7.2	12	4.1	2	1.6	1	1.9		
28	Department manager...	F			18	1.8	12	1.6	7	1.4	4	1.4	2	1.6	1	1.9		
29	Department Supt........	H	4	.4	40	4.0	29	3.9	17	3.5	4	1.4						
30	Master mechanic.........	H			2	.2	5	.6	5	1.0	2	.7						
31	Assistant editor..........	G			3	.3	6	.8	1	.2								
32	Assistant manager.......	F	1	.1	19	1.9	9	1.2	3	.6								
33	Asst. master mechanic..	H	1	.1	3	.3												
34	Assistant professor	G	2	.2	16	1.6	12	1.6	3	.6	1	.3						
35	Assistant sales engineer.	F			14	1.4	1	.2	1	.2								
36	Asst. superintendent....	H	3	.3	64	6.3	16	2.1	6	1.2	3	1.1						
37	Experimental engineer.	G			8	.8	2	.3										
38	Investigating work......	G	6	.6	8	.8	4	.5	4	.8	2	.7						
39	Erecting engineer........	H	2	.2	55	5.4	16	2.1	2	.4								
40	Foreman	H	1	.1	15	1.5	2	.3										
41	Inspector	H	9	.9	24	2.4	3	.4	1	.2	1	.3						
42	Instructor..................	G			17	1.7	3	.4	1	.2								
43	Insurance inspector	F	2	.2	11	1.1	5	.7	1	.2								
44	Paymaster..................	F	1	.1														
45	Apprentice.................	J	100	9.6	1	.1												
46	Chemical work..........	G	16	1.9	2	.2												

TABLE I.—*Continued.*

Identifying Numbers.	Positions.	Group Letters for Fig. 2.	Total Number and Percentage of Graduates Holding Positions Mentioned.															
			Immediately after graduation. Total number that have been graduated 5 yrs. or more, 1,039.		Years after Graduation—Total Number of Graduates Living													
					5 years. 1,009.		10 years. 754		15 years. 485		20 years. 282		25 years. 115		30 years. 52		35 years. 1	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
47	Clerical & com'ial work.	F	20	1.9	12	1.2												
48	Draughtsman	J	384	37.0	53	5.3	7	.9	1	.2								
49	Editorial work	G	5	.5	6	.6												
50	Miscellaneous eng. work	J	315	29.8	125	12.4	21	3.0	4	.8								
51	Rodman	J	7	.7														
52	Students—architecture.	G	1	.1	1	.1												
53	Art	F	1	.1	1	.1												
54	Chemistry	G	5	.5														
55	Classical & theology	F	2	.2	2	.2												
56	Engineering	G	15	1.5	3	.3												
57	Law	F	4	.4	5	.5												
58	Marine engineering	G	3	.3														
59	Medicine	G	2	.2	1	.1												
60	Mining	G	4	.4														
61	Patent law	G	8	.8	1	.1	1	.2	1	.2								
62	Surveying work	J	10	1.0	1	.1												
63	Teaching	G	34	3.3	4	.4												
64	Testing work	G	18	1.7	7	.7												
65	No record	K	26	2.5	38	3.8	36	4.7	18	3.7	9	3.2	4	3.5	1	1.9		
	Totals		1,039	100.0	1,009	100.0	754	100.0	485	100.0	282	100.0	115	100.0	52	100.0	1	100.0
	Deceased				30	3.0	13	1.7	10	2.0	14	5.0	1	.8				

These records are as accurate and as complete as circular letters, and follow-up correspondence, could make them. To complete the records of positions held from 1905 to date the institute catalogues were used. A further source of advantage in making up Table I. was found in the fact that the author is personally acquainted with over 70 per-cent. of all the graduates, and, through alumni offices and a five-year period as editor of the *Stevens Institute Indicator,* was in close touch with the positions held and the work done by many of the men.

FIG. 1.

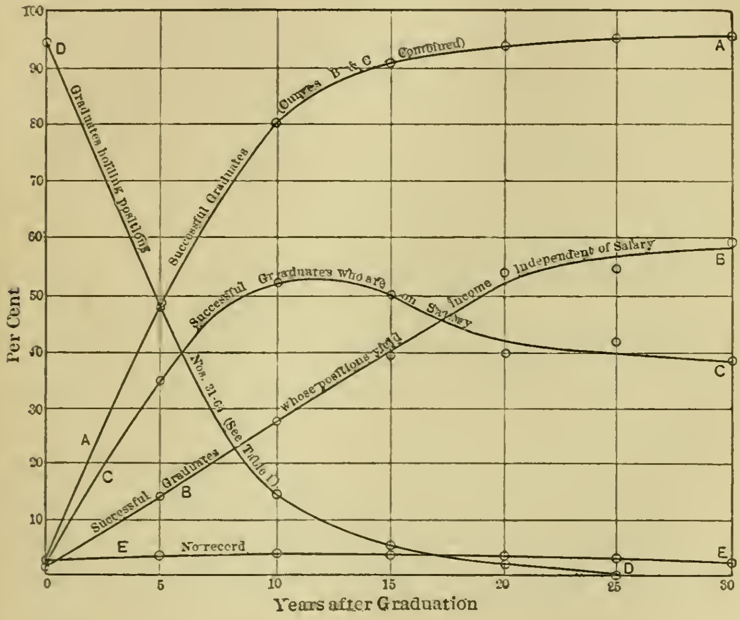


Fig. 1, showing the measure of success attained by the graduates of Stevens Institute, comes directly from a grouping of items in Table I. A man has been termed successful at each of the five-year periods if he is engaged in business on his own account or in association with others, or, when he is in a salaried position, if he is directly responsible for a business or for an important branch or department of a business. Such men as are here defined are enumerated in items 1 to 30 of Table I, and are represented in Curve *A*, Fig. 1. Curve *A* is a combination of Curves *B* and *C*.

Curve *B*, Fig. 1, shows the percentages of successful graduates who have engaged in business or professional work on their own account or in association with others, and who have income from their current labor independent of salary. These men are listed in items 1 to 17 of Table I. An example of the method of obtaining Curve *B* may be shown by taking the ordinate at the fifth year, where it is seen to be about 14 per cent.; this should correspond with the sum of the percentage items in the first seventeen lines of the five-years column of Table I., which sum is 13.7.

Curve *C*, Fig. 1, shows the percentage of successful graduates who are on salary, being responsible for a business or for an important branch or department of a business. These men are shown in items 18 to 30, Table I.

Curve *D* shows the percentage of men holding minor positions, or engaged as assistants to various officers, and is made up from items 31 to 64 of Table I.

Curve *E* shows the percentage of men of whom no record could be obtained, ranging from 2 to nearly 5 per cent., and corresponds with item 65 of Table I.

COMMENTS ON FIG. 1.

Curve *B* shows the application of the general law underlying the ambitions of a vast majority of men to become independent in thought and in action in the affairs of life. Applied to the graduates in mechanical engineering, we find them steadily rising, those having the benefit of family financial aid probably maintaining the steadily increasing line to about the tenth year, when their brothers from the humbler walks of life, through savings due to sustained perseverance and economy, and also, perhaps, borrowing capacity due to good reputation, join them in their high business positions as owners or partners.

TABLE II.

SHOWING PERCENTAGES ON WHICH CURVES IN FIG. 1 ARE BASED.

	Immediately after graduation.	Years after Graduation.						
		5	10	15	20	25	30	35
	%	%	%	%	%	%	%	
Total per cent. of successful graduates. Curve *A*, Fig. 1. (Also items 1–30, Table I.)...	3.1	48.3	80.7	90.5	94.4	96.5	98.1	
Successful graduates whose positions yield income independent of salary. Curve *B*, Fig. 1. (Also items 1–17, Table I.)...	1.7	13.7	28.3	39.6	54.8	54.4	59.6	
Successful graduates who are on salary. Curve *C*, Fig. 1. (Also items 18–30, Table I.).	1.4	34.6	52.4	50.9	39.6	42.1	38.5	
Graduates holding minor positions. Curve *D*, Fig. 1. (Also items 31–64, Table I.).	94.4	47.9	14.6	5.8	2.4			
Graduates whose records are unknown. Curve *E*, Fig. 1. (Also item 65, Table I.).........	2.5	3.8	4.7	3.7	3.2	3.5	1.9	
Totals........................	100.0	100.0	100.0	100.0	100.0	100.0	100.0	

At the tenth year a most noticeable and decided readjustment in business standing begins and continues to the twentieth year. During this period the frugal and industrious graduates in mechanical engineering, shown by Curve *C*, comes into his own in maximum numbers by changing over from the position of a receiver of salary to that of a payer of salary. After the twentieth year the rate of change from the one class to the other decreases and the chances of a man becoming his own master are rapidly waning.

Curve *D*, showing the percentage of men holding minor positions, is naturally largest at the start and decreases as the curve of successful men rises, both curves crossing at 48 per cent. after five years. This points to the facts:

That the fifth year is the first critical stage of the technical graduate's career, and that he should carefully consider his present and future at this time. If he is one of the successful graduates and is ambitious, he should take thought in the matter of a high standing among his fellows. If he is not in one of the successful positions, he is in the lower half and should take serious thought and perhaps redouble his efforts that he may be among the first of his group to enter the class of successful men; and:

That those interested in the young graduate should not too hastily judge whether or not his first five years of labor are leading him to a bright career. This period of labor and perhaps drudgery carries with it equal chances for large reward.

Curve *E* shows the men whose addresses and records are unknown, the average being 3.2 per cent.

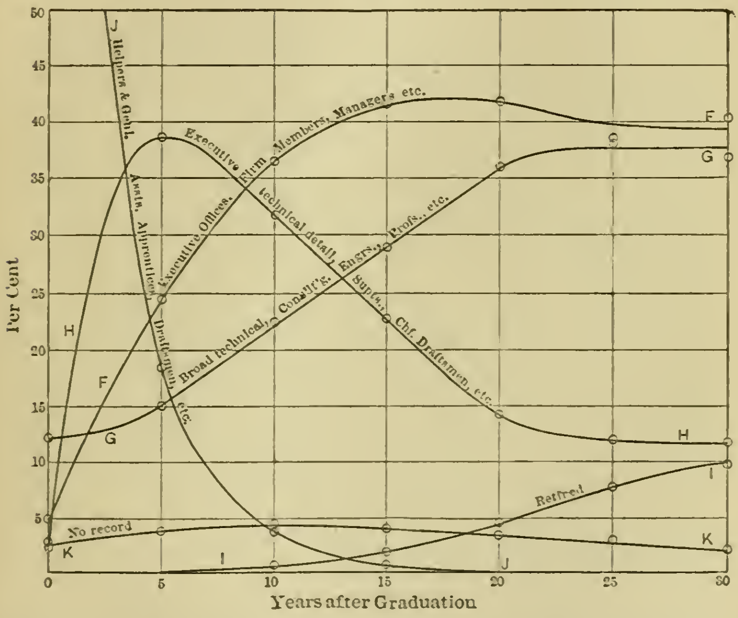
COMMENTS ON FIG. 2.

Fig. 2, showing the character or nature of work engaged in by graduates in mechanical engineering, is also derived from Table I. by a special order of grouping.

The curves show the percentages of graduates that have taken up work calling for:

First. An executive or managerial ability, in most cases combined with the requirement of a certain amount of technical knowledge for such officers as presidents, managers, sales engineers, etc. (See Curve *F*.)

FIG. 2.



Second. A broad application of technical knowledge for such as consulting engineers, professors, etc. (See Curve *G*.)

Third. A detailed technical training for such as superintendents, chief draughtsmen, etc. (See Curve *H*.)

Curve *I* shows the percentage of men that have retired from business, or from professional work.

Curve *J* shows the difficulty of properly classifying graduates in the scheme of Fig. 2 for their first few years, but that thereafter they rapidly develop, according to their natural bent and their college training, into one of the classes represented by Curves *F*, *G* and *H*.

The curves in this figure show that the broad technical course, planned by President Morton and his original faculty for the Stevens Institute thirty-seven years ago for the training of the mechanical engineer, for which there was then no precedent in this country, was timely, and that the results then hoped for have been achieved.

That this broad technical training has not prevented the development and growth of the commercial instinct is shown by the well-balanced proportions between Curves *F* and *G* after the men have become settled in life. It must be remembered that it is the youth with the technically studious, rather than the purely commercial nature, that seeks a course in mechanical engineering, and the fact that in spite of this the largest percentage of the graduates are drawn to the commercial rather than the technical side of the profession shows that there is a substantial demand in the business world for the graduate in mechanical engineering in the high administrative offices.

TABLE III.

SHOWING PERCENTAGES ON WHICH CURVES IN FIG. 2 ARE BASED.

	Immediately after graduation.	Years after Graduation.						
		5	10	15	20	25	30	35
		%	%	%	%	%	%	%
Graduates holding executive positions, such as firm members, managers, etc. Curve *F*, Fig. 2. (Also items marked *F* in Table I.)	4.6	24.3	36.5	41.8	41.8	38.6	40.3	
Graduates holding positions requiring broad technical training, such as consulting engineers, professors, etc. Curve *G*, Fig. 2. (Also items marked *G* in Table I.)	12.1	15.0	22.7	28.9	36.1	38.1	36.6	
Graduates holding positions calling for executive ability in technical details, such as superintendents, chief draughtsmen, etc. Curve *H*, Fig. 2. (Also items marked *H* in Table I.)	2.7	39.0	31.7	22.7	14.7	11.9	11.5	
Graduates occupying positions as helpers, general assistants, such as apprentices, draughtsmen, etc. Curve *J*, Fig. 2. (Also items marked *J* in Table I.)	78.1	17.9	3.9	1.0				
Graduates who have retired from business or professional work. Curve *I*, Fig. 2. (Also item marked *I* in Table I.)	......	......	.5	1.9	4.2	7.9	9.7	100.0
Graduates whose records are unknown. Curve *K*, Fig. 2. (Also item marked *K* in Table I.)	2.5	3.8	4.7	3.7	3.2	3.5	1.9	
Totals	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

This demand has, in late years, been increasingly recognized in most of the engineering schools, first at Stevens, when Mr. Alexander C. Humphreys, now President Humphreys, in 1897 inaugurated a series of lectures on business engineering in regularly provided roster time. These lectures extended over increasingly longer periods until 1902, when the department of business engineering was organized. Regular weekly lectures and recitations have since been held throughout the entire year.

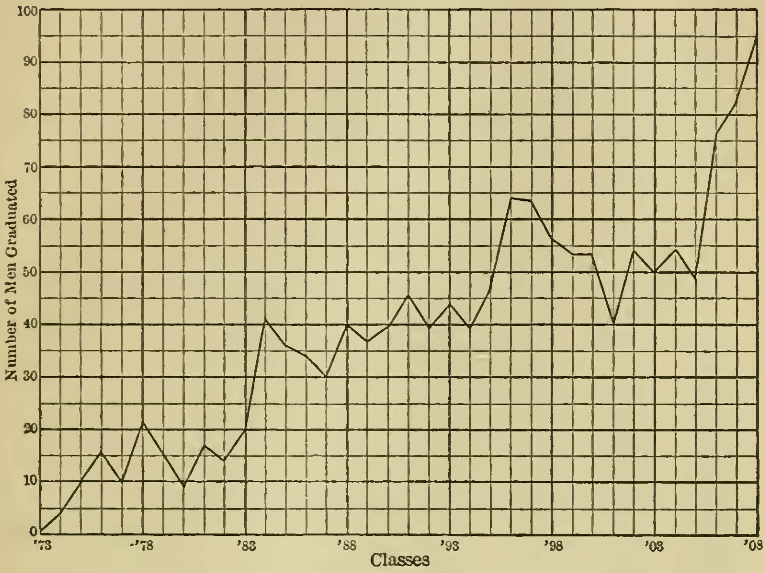
The falling off of graduates in executive and managerial positions after the twentieth year, as shown in Curve *F*, is fully accounted for by the rise in Curve *I*, which records the number that have retired from active business or professional work.

Curve *H* shows that the technical schools have before them a most difficult problem in determining the proper proportion between breadth and detail in training. The young graduate during the first five years, as shown by the rapid rise of the curve at the start, is needed and is doubtless best fitted to do detail work; through this he passes after his fifth year into work of either a broader technical or of an executive nature according to natural aptitude and circumstances.

Curve *H* shows, perhaps unfortunately, a considerable drag from the fifth to the twentieth years. This, it is believed, can be lessened more rapidly only through hard and intelligently directed work during the first five years. Those who have best prepared themselves during this period will be drawn first from the comparatively slow-falling part of the curve.

Fig. 3 is a diagram showing the number of graduates in each class and is of interest here as illustrating the rate of growth of the institution whose work is being analyzed. It will be remembered that only the degree of mechanical engineer is given at Stevens. It should be added, however, as a matter of record, that seven exceptions were made in the early days of the Institute, when the degree of B.S. was conferred upon two, and that of Ph.D. on five men. One of the B.S. degrees was advanced at a later date to

Fig. 3.



Ph.D. The data on which Fig. 3 is based are given in Table IV.

Tables II. and III. give the co-ordinates on which Figs. 1 and 2 are based, respectively.

General Observations.

In the preparation of this paper a number of facts bearing on the subject, but which have found no place thus far, have come to light.

One of the most important is, that it is necessary to consider *all* of the graduates to obtain reliable data.

When this paper was suggested, I planned to issue a circular letter and make up my results from uniformly tabulated replies. The circular was issued, but only a little over 300, or one-quarter of the total alumni body, responded to the first call. There was not time to issue follow-up circulars before the convention meeting at Detroit. It then occurred to me to make use of the "Morton Memorial Volume" wherein the successive occupations of all the graduates were recorded, as already stated.

TABLE IV.

NUMBER OF GRADUATES BY CLASSES.

Class.	No. of Graduates.	Class.	No. of Graduates.
1873	1	1891	45
1874	3	1892	39
1875	10	1893	43
1876	17	1894	39
1877	10	1895	47
1878	22	1896	64
1879	14	1897	63
1880	9	1898	57
1881	17	1899	53
1882	14	1900	53
1883	20	1901	40
1884	42	1902	54
1885	36	1903	50
1886	33	1904	54
1887	30	1905	48
1888	39	1906	76
1889	36	1907	83
1890	39	1908	94
	392		1,002
			392
		Total	1,394

Since the convention I have tabulated and plotted, on parallel lines, the data from the 300-odd replies, and find that while the curves correspond in a general way with those in this paper, the more successful men are the ones who have answered generally. This is shown by the fact that the curve of successful men for the 300 replies shows 89 per cent. at 10 years, whereas the similar curve in Fig. 1 of this paper shows only 81 per cent.

It also develops that those in executive or managerial positions are more responsive than those in the more professional lines of work, as shown by the

TABLE V.

LINES OF WORK IN WHICH GRADUATES IN MECHANICAL ENGINEERING ARE ENGAGED.

			No.	Per Cent.
Machinery and instrument manufacturing companies....			244	18.7
General manufacturing work:	No.	Per Cent.		
Engineering products (pipe and carbons, for example)........	71	5.47		
Mercantile products (hats and silk goods, for example)........	68	5.23	139	10.7
General engineering work........			133	10.3
Gas or electric light work (including gas plant construction)........			115	8.8
Professional engineering work........			102	7.8
Instruction work........			63	4.9
Railroad work........			49	3.8
Structural work (both steel and concrete)........			40	3.1
Public works........			36	2.8
Iron and steel mill work........			35	2.7
Street railway work........			29	2.2
Insurance work (life, fire and accident)........			28	2.1
Lawyers and patent lawyers........			23	1.8
Mining work........			18	1.4
Banking and brokerage work........			11	.8
Journalistic work........			9	.7
Chemical manufacturing work........			9	.7
Private interests........			8	.6
Marine engineering work........			7	.5
Miscellaneous (on engineering or mechanical lines)........			43	3.4
Miscellaneous (on mercantile or non-engineering professional lines)........			29	2.2
Unknown........			31	2.4
Retired........			14	1.1
Deceased........			85	6.5
Total, not including class of 1908........			1,300	100.0

curve of administrative officers for the 300 replies reaching 50 per cent. at twenty years against 42 per cent., as shown in the similar curve (*F*) in Fig. 2, while the curve for the more professional men for the 300 replies reaches only 34 per cent. against 36 per cent. in Fig. 2.

The question as to the number of technical graduates that start in the draughting room is one that frequently comes up and is well answered in Table I., where it is shown that 37 per cent. begin there, 10 per cent. (including chief draughtsmen) are thus employed after five years, and 3 per cent. after ten years.

In following up the records of graduates the writer has been impressed with the fact that a large percentage of the older ones especially, that now stand highest in their professional work, are those who have started in as machine-shop apprentices. The apprenticeship course of one to two years immediately after graduation has stamped itself as the surest road to eminent success in later years.

TABLE VI.

GRADUATES EMPLOYED BY LARGE CORPORATIONS.

	No.	Per Cent.
Railroads	49	3.8
Public works	36	2.8
United Gas and Improvement Co.	33	2.5
Westinghouse interests	27	2.1
General Electric Co.	20	1.5
Street railway systems	20	1.5
Telephone and telegraph companies	13	1.0
Edison Co.	11	.8
Standard Oil Co.	7	.6
International Pump Co.	6	.5
American Sugar Refining Co.	5	.4
Miscellaneous	19	1.5
Total	246	19.0

A trifle less than 5 per cent. of all the graduates have entered occupations that are in no way associated with manufacturing or engineering work.

An interesting fact, proving that pluck and perseverance are necessary in engineering in winning the higher positions, is shown by the notably large number of salaried men who have attempted to take up independent work, principally as consulting engineers and firm members, but who have had to fall back to salaried positions from time to time. This applies more particularly to the period of five to fifteen years after graduation. It does not show in the tables or the curves, for these men have eventually won out, and, taken as a whole, have marched steadily onward and upward as shown in Curve *B*, Fig. 1.

A number of men who have been classed as owners of a business, presidents, etc., at one period, have had to be changed over to the salaried position class as superintendents, managers, etc., at another period, on account of the formation of large corporations, or "trusts." But for this, it is quite likely that Curve *B*, Fig. 1, would continue to rise at a more uniform rate after the twentieth year and that Curve *C* of salaried positions would fall correspondingly. These same business combinations have in some cases compelled a man to step from chief engineer in the small firm to the lower rank (but often a really larger position) of department engineer in the larger corporation.

In a number of cases men are engaged in two or more occupations, such perhaps as professor and consulting engineer, or officer of a firm and consulting engineer, in which cases only one office, of course, has been taken, and that the one to which the person was giving the most time and attention so far as could be judged. The items "firm member" and "owner of a business," Nos. 4 and 5 in Table I., include chiefly members of firms that are engaged in manufacturing, or specific engineering lines. Many who are consulting engineers are also "firm members" or "owners of a business," but are here recorded as a rule in their professional capacity. The offices of vice-president and manager are often combined, the former title being the one generally recorded in this work. Here again it was necessary to consider each case with the data and knowledge at hand and enter accordingly, for the proportion of the independent and salary curves of Fig. 1 is affected.

In making up Table I. a much larger number of occupations than the 64 shown were originally listed. It was necessary, however, to keep down the bulk of this table, and many occupations or offices in which one may be engaged will not be found. They are, however, all merged with one or another of the items according to the knowledge of the man, most of the omitted items being classed with "department engineer." In some places "department engineer" means more than "chief engineer" in others, but the smooth curves indicate that the knowledge of the men and the law of averages serve to keep the record about right.

Where graduates have started in as consulting engineers, chief engineers, superintendents, etc., it has generally been the case that the men were older than the average and that they had had considerable experience before coming to the institute.

It has frequently happened that men have held higher titles during the intermediate years than on the fifth, tenth, fifteenth, etc., but it is believed that by adhering strictly to the five-year period a fair average has been obtained.

The term "cadet engineer" is one that has been frequently used by young graduates, especially those going into gas engineering work, but it is not included in this list for the reason that a great many more are positively known to have started in under this title than are so recorded. Rather than understate this important position, for it is to the gas business what the shop apprenticeship course is to the machine manufacturer and engineer, it has been classed in with "miscellaneous engineering work." The same might be said of the student courses in the large electrical manufacturing companies.

In response to the circular sent out for information for this paper, a number of the graduates took occasion to write their views in addition to filling out the forms. These are of interest and value in the study of this subject, coming as they do from graduates who have had a varied, and in most cases a highly successful experience. The following are extracts from some letters, selected to show the several points of view of graduates in various lines of work.

From one who has had an excellent chance for observation:

"My own personal opinion after eighteen years of experience is that a technical education is of the greatest value, and if the graduate will content himself to begin at the very bottom of the ladder and work, not for the salary which he may think he ought to receive, but with the idea that within ten years he shall attain a position of responsibility, if not independence, he will certainly get it. The greatest difficulty we have to contend with these days in the employment of young engineers is the feeling on their part that their efforts are not sufficiently appreciated. If the hours that are spent in trying to devise ways and means to raise their salaries were spent in application to the work intrusted to their care the salary question would take care of itself. In our firm we have many technical men of several nationalities—American, English, German and Japanese—which has given me an unusual opportunity to study human nature, especially technical nature, and the above observation holds fairly true of all. Our firm has a great variety of departments—textile, metals, glass, timber, cereals, fertilizers, finance, and engineering—as well as actual machinery manufacture, and my attention has often been struck by the manner in which aid is sought of the engineering department whenever troubles are encountered. I have had good chances to see for myself the advantage of an engineering education and am a thorough believer in it."

From a member of a general engineering firm:

"The technical graduate who possesses both a good engineering and business training has a considerable advantage over the man with a commercial training only. I think that a conservative estimate of the advantage due to the technical training, in men of the same native ability, would be from 25 per cent.

to 50 per cent. over the man with the commercial training only; this is allowing for the fact that the commercial man has had a longer training in that line than has the man with the dual training. The degree of advantage bestowed by the dual training will, of course, vary with the excellence of the balance maintained between the two and the field of business in which they are employed."

From one who worked his way up through minor positions and at the end of his tenth year was half owner of a manufacturing business. He is now a part owner of five different manufacturing plants all devoted to the production either of machine parts or of engineering rather than commercial products. He also stated in the circular form that his present position as owner of a business, firm member, etc., *is due entirely to his own resources*—that is, without the aid of family inheritance, etc.:

"Reference to the enclosed form will show that my real material progress began after I had abandoned engineering work. Reference to my record at Stevens will show that I was always well above the average in all my studies, taking the entire course without a condition. My later record would perhaps show that it is pardonable for me to assume that I am not deficient either as a manufacturer or business man, and yet, as long as I devoted myself to engineering purely, I was only able to make rather unsatisfactory headway.

"I believe there are too many high-class engineering colleges. The profession is over-stimulated.

There are to-day one thousand highly trained and really competent engineers doing such work as a draughtsman or any ordinary bright high-school boy could do after one year's practical experience in a draughting room. I could cite special cases that have come under my notice of efficient men, graduates of good western institutions and several years out of college, who are doing work that could easily be done by a bright messenger boy. I feel that I owe absolutely nothing to my alma mater except a few wasted years. I regret that this should be so. I know that this opinion will not be well received, but I believe it is time that this 'jollying' and self-glorification should be stopped and some honest words be said on the other side. There are too many engineering colleges, not enough trade schools."

From one who is a leading member of a large mercantile manufacturing firm but whose office is entirely independent of engineering or technical work:

"I do not know that it would properly come within the scope of your paper, but I would like to see more stress put upon the by-products of engineering education. Herbert Spencer wrote, 'so that only by giving us some utterly different mental constitution could the process of civilization have been altered.' It would seem to me that the attention now being given to scientific and engineering studies may induce a different mental constitution and thereby be a blessing to the world. I have an abiding faith in the disciplinary value of engineering education."

From one man who has built up a large business in consulting engineering and patent work:

"All my profits have been the direct result of *technical* knowledge acquired at Stevens, and subsequent self-education and experience."

From one who has been graduated nearly twenty years and is now superintendent of important work:

"I entered Stevens after leaving the machinist's trade, and this preliminary training coupled with the college education has been of the greatest value."

From one successfully engaged in a special line of ranch work after a varied experience of more than fifteen years:

"While —— is not a branch of mechanical engineering, I have found many uses for what knowledge I possess of the subject, and if I had a son to educate, should have him learn engineering of some class. I believe it fits one for quick and accurate thinking, develops one's powers of observation, and would be of considerable benefit for anyone."

From one who is managing director of one of the world's largest branch organizations:

"I cannot say that my modest success is the direct result of engineering, but I do believe that the ten years of engineering work after graduation made my present position possible."

From one who has been connected with large industrial corporations for more than fifteen years:

"I consider that most engineering positions with large corporate interests require executive ability combined with engineering knowledge and that an engineering education is about the best foundation for almost any position of large responsibility."

From a member of a well-known firm of architects:

"I consider myself more architect than engineer, but never could have made my present position without the Stevens training and my early experience."

From one engaged in commercial work for a well-known electrical engineering company:

"An engineering education is a necessity for a man desiring to engage in commercial work in the electrical field. The positions in the sales departments of the —— company are nearly all filled by technical graduates who have served in the engineering department."

From an eminent consulting engineer who has earned the distinction of being the leading American authority in the branch of the profession to which he is devoted:

"Had to make my own way without aid of any kind. Had to build up my own influences."

The last sentence of the above quotation is suggested by the author of this paper as a worthy one for every young graduate to bear in mind.

TABLE VII.

SHOWING SPECIALTIES IN WHICH THE STEVENS GRADUATES ARE ENGAGED.

Acetylene generators.
Actuaries.
Advertising.
Agricultural implements and machinery.
Air brakes.
Air compressors.
Air pumps.
Air lift pumps.
Ammonia valves and fittings.
Annealing furnaces.
Appraisers.
Architects.
Artesian wells.

Artificial stone.
Asbestos.
Asphalt.
Assayer.
Automatic machinery.
Automobile manufacturers and sales agents.
Axles.

Babbitt metals.
Ball bearings.
Banking.
Barrel manufacture.
Batteries, electric.
Beet sugar machinery and manufacture.
Belt conveyors.
Belt lacing.
Billing machines.
Biscuit manufacture.
Blast furnace work.
Blowers and exhaust fans.
Blue printing apparatus.
Boat builders.
Boilers.
Boiler coverings.
Bolt and nut manufacturers.
Bookbinders.
Bottling apparatus.
Brakes.
Brass and bronze bearings.
Brass rolling mill.
Brass wire and metal goods.
Brewers.
Bricks.
Bridge builders.
Brokers—insurance, bond, stock and general.
Brushes for motors and generators.
Builders and building materials.

Cables, wire and insulated.
Caissons.
Calculating machines.
Canned goods.
Carbons and carbon brushes.
Carbonating apparatus.
Carburetted water-gas plants.
Cars.
Car couplers.
Car heaters.
Car lighting.
Car seats, car wheels, etc.
Castings.
Casualty companies.
Cement.
Chemicals.
Chemists.
Chimneys.
Civil service examiners.
Clergymen.
Clocks.
Coal handling machinery.
Cold storage.
Coke and gas plants.
College presidents and college professors, etc.
Concrete buildings and concrete-steel construction.
Condensers, steam.
Conduits.
Consulting engineers.
Contractors.
Conveying machinery.
Cooling towers.
Copper mining, copper refining, copper rolling mills, etc.
Core drilling.
Correspondence instruction.
Cost-keeping devices.
Cotton gins, cotton ginning machinery.
Cotton manufacturers.
Cotton oil, cotton-seed oil mills, etc.
Cranes.

Dams.
Designers of machinery, power plants, etc.
Diamond tools.

Distilling apparatus.
Dock builders.
Doctor.
Draughtsmen.
Dredging and dredging machinery.
Drills and drill chucks.
Dry docks.
Drying apparatus.
Dyers of silk, cotton and wool.
Dynamos.

Editors.
Electric clocks, controllers, elevators, generators, lamps, light and power companies, motors, railways, railway supplies, signs, specialties, switches, etc.
Electrical contractors and experts.
Electrical instruments.
Electro-chemistry.
Electrolysis.
Electro-magnet machinery.
Elevators.
Emery presses.
Engines—steam, gas, steering.
Engineers—architectural, bridge, chemical, civil, consulting, constructing, contracting, designing, electrical, gas, heating, hydraulic, insurance, marine, mechanical, mining, natural gas, ordinance, power plant, park, public works, railroad signal, railway, sanitary, structural, sugar, ventilating, etc.
Engineering economics.
Examiner of patents.
Excavating machinery.
Experimental work.
Exporters and importers.

Factory accounts.
Factory construction.
Factory managers.
Fans.
Feed-water heaters.
Filters and filter presses.
Fire alarms and fire extinguishers.
Fire insurance.
Fluorescence screens.
Flooring.
Flour manufacturer and flour mill machinery.
Forest land development.
Forges and forgings.
Foundations.
Foundry supplies.
Friction clutches.
Fuel economizers.
Fuel oil appliances.
Furnaces.

Galvanizers.
Gas buoys and beacons.
Gas engines, generators, light companies, machinery, producers, appliances, etc.
Gauges, pressure and vacuum.
Geologist.
Gold dredging machinery.
Gold milling machinery.
Gold refining.
Governors—steam engine and gas.
Graphite.
Greenhouses.

Hardware manufacturer.
Hat manufacturer.
Harvesting machinery.
Heating apparatus, heating, lighting and power plants, heating and ventilating.
Hoisting and conveying machinery.
Hotels.
Hot-air engines.
Hydraulic machinery, presses, rams, etc.

Importers.
Incandescent electric lamps and filaments.
Incandescent gas lamps, mantles.

Indicators, steam-engine.
Industrial railroads.
Injectors.
Ink rollers.
Instructors.
Insurance—accident, fire, life and marine.
Investigations.
Inventors.
Iron and brass fittings.
Iron foundries.
Iron workers, ornamental and structural.

Jewelry manufacturer.
Journalism.

Kerosene engines.
Kilns.

Labor-saving devices.
Lamps, arc and incandescent.
Landscape architect.
Launches.
Lawyers.
Lead manufacturer.
Leather goods, leather tires, artificial leather.
Licorice manufacturer.
Lighting plants.
Locks.
Locomotives.
Lubricants.
Lumber.

Machine tools.
Machinery.
Magnesia.
Marble machinery.
Manual training.
Manufacturer's agents.
Manufacturers' supplies.
Marine architects.
Marine engines, pumps, plumbing.
Masons and builders.
Mathematical instruments.
Measuring instruments.
Mechanical stokers.
Merchants.
Metallurgists.
Metals, perforated.
Minerals.
Mineral waters.
Mining and mining machinery.
Model and experimental work.
Motor boats.
Motor cars.
Motors, electric railway, gasoline.
Music-playing apparatus, electric.
Music teacher.

Naval constructor.

Office systems.
Oils, oil burning, oil engines.
Oil-drilling supplies.
Oil and natural gas, oil refining, oil concentration.
Oyster grower.

Packing cans.
Packing-case manufacturer.
Paper-box manufacturer.
Paper manufacturers.
Park superintendent.
Patent attorney.
Phosphate.
Physical laboratories.
Pipe and fittings.
Pipe lines.
Plate-steel work.
Ploughs.
Plumbago, plumbago plates.
Plumbers' supplies.
Plumbing.
Pneumatic tools.
Power companies, power developments, power plants, power transmission.
Preserved fruit.
Presses, die and tool.
Pressure blowers.

Print works.
Printers.
Printers' rollers.
Promoters.
Pulp manufacture.
Pumps, artesian well and turbine.
Pumping engines, pumping machinery, pumping plants.
Purchasing agents.
Pyrometers.

Radiators.
Rail joints.
Rails.
Railway construction.
Railway maintenance.
Railway repair shops.
Railway signals.
Railway supplies.
Real estate.
Recording instruments.
Refrigerating engineers, refrigerating machinery.
Registers.
Reinforced concrete construction.
Rheostats.
River and harbor improvements.
Rock drills.
Rock and ore crushers.
Rolling and mill machinery.
Rope.
Rubber goods, rubber manufacture.

Safes and bank vaults.
Sales agents, sales engineers.
Salt manufacture.
Saw-mill machinery.
Scientist.
Screening machinery.
Seamless tubes.
Separators.
Sewage purification.
Shafting.
Shapers.
Sheet-metal goods, sheet-metal work.
Shop management.
Silk machinery, silk manufacturer.
Silver rollers.
Silversmiths.
Smelters.
Soaps and perfumes.
Special machinery.
Speed indicators.
Stacks.
Statisticians.
Steam boilers.
Steam engines.
Steam fitters.
Steam hammers.
Steam heating.
Steam pumps.
Steam shovels.
Steam superheaters.
Steam traps.
Steam turbines.
Steel axles.
Steel barrels.
Steel castings.
Steel construction.
Steel manufacturers.
Steel works.
Stone, artificial.
Storage batteries.
Stove manufacturers.
Street railways.
Structural steel and iron work.
Suction cleaners.
Sugar machinery.
Sugar refiners.
Sulphur refining.
Surveyor.
Switchboards.

Table delicacies.
Tanks.
Tanners' machinery.
Tanning extracts.
Teachers.
Telegraph.
Telephones, telephone exchanges, telephone supplies.

Testing laboratories, testing materials.
Textile machinery.
Thermometers, recording thermometers.
Thermostats.
Tile manufacturers.
Tobacco manufacturer.
Transformers.
Tubing.
Tunnels, tunnel building.
Turbines, steam and water.
Typesetting machinery.
Typewriters.

Vacuum pans and pumps.
Valves, valve manufacturers.
Vehicle manufacturers.
Veneer manufacturers.
Veturi water meters.
Voltmeters.

Watch-case manufacturers.
Water-gas plants.
Water meters.
Water power.
Water softeners.
Water works.
Window glass.
Wine producer.
Wire-drawing machines.
Wire nails.
Wire rope.
Wireless telegraphy.
Woolen machinery.
Works management.
Wrecking work (marine).

Yacht broker.

DISCUSSION.

PROFESSOR WILLISTON: I have brought two charts that I think will be of interest to the Society in connection with Professor Furman's paper. They were prepared for another purpose, but they show the earning power of the young men who have graduated from the two year courses in the School of Science and Technology at Pratt Institute. This kind of data is the one thing which appears to be lacking from the information that Professor Furman has collected, and these charts that I have brought, reproduced in Fig. 1 and Fig. 2, show it admirably. They give the average professional earning power of the men each year after graduation. The horizontal lines in the figures represent $500, $1,000, $1,500, $2,000, $2,500, and $3,000 respectively, and the height of the vertical ordinates from the bottom of the diagrams to any one of the curves represents earning power at the corresponding time. The abscissæ or the distances from the left hand edge of the diagram to the various vertical lines represent the number of years since graduation. The height of the curves at the left hand edge of the diagram, therefore, represents earning power immediately after graduation, and the height of the curves at the right hand side of the diagrams represents earning power twelve years after graduation in Fig. 1, and ten years after graduation in Fig. 2.

These classes were small ten or twelve years ago, and therefore the data regarding the earning power of the men who have been out approximately that length of time is somewhat unreliable, as it is averaged from the results of the experience of but comparatively few individuals. For this reason the ends of the curves in both figures are shown as dotted lines. The balance of the curves, where the lines are shown full, represents the average results of the experience of a very much larger number of men, and consequently is correspondingly more accurate. The heavy curve in the center of the cross-hatched area in each figure shows the average earning power for the entire class. The top curve, forming the upper boundary of the cross-hatched area, shows the average earning power of the 20 per cent. of the class making the best records; and the bottom curve, which forms the lower boundary of the cross-hatched area, shows the earning power of the 20 per cent. of the class making the poorest financial records.

Fig. 1 gives the experience of the graduates of our two-year course in Steam and Machine Design. It shows an earning power at graduation of a trifle over

$750, which increases up to an average of about $1,900, twelve years after graduation. The upper line, giving the average of the best fifth of the class, shows an initial earning power of $1,150, and increases up to about $3,000. The lowest fifth of the class started at $500, and increased the earning power up to about $1,500, in twelve years.

Fig. 1.

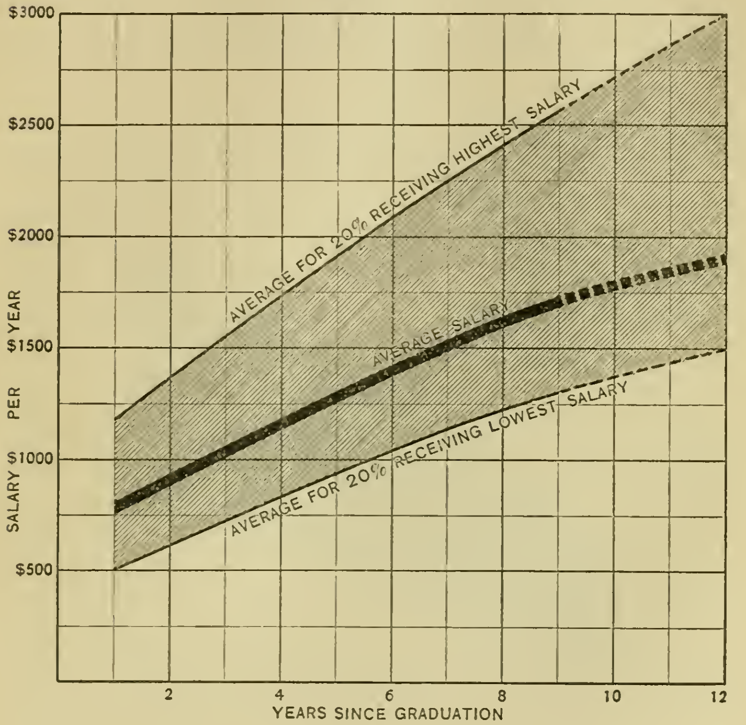
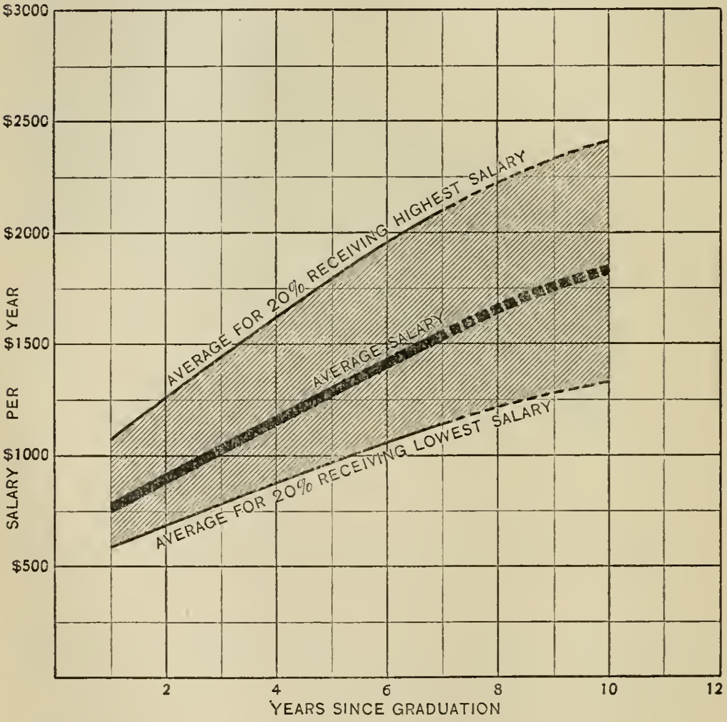


Fig. 2 gives the corresponding data for the graduates of our two-year course in Applied Electricity. This course has been in existence only long enough to get the records for ten years after graduation.

The curves for it, however, correspond almost exactly with those for the Steam and Machine Design course; and it is especially interesting to note the closeness of the agreement, for the data is taken from an entirely different group of men who come to the Institute with a somewhat different practical experience, and who go out into an entirely different field of work.

FIG. 2.



In comparing the information in these curves with corresponding data from other schools it should be borne in mind that these are not courses for engineers, but are short two-year courses of very practical character, intended to give the foundation training to those who wish to hold later positions of foremanship or master-mechanic type. The men who enter them have had, as a rule, little and sometimes no high school training. Many of them, on the other hand, have had a considerable amount of practical experience. The curves do not give, therefore, the earning power that graduates of engineering schools may expect, but, instead, the average expectancy of intelligent and capable young men in manufacturing plants who have taken two years to educate themselves for positions of more importance or responsibility than those of the skilled mechanic. The curves, thus interpreted, throw considerable light upon the possible cash value of two years of technical training. It is interesting, too, to discover that ten or twelve years after graduation the curves still keep on rising and that there is no indication that we have yet reached, or are even approaching the point where the curves will turn and become horizontal, or nearly horizontal.

As these courses, for which this data was gathered, are intended to train young men who wish later to hold positions of foremen, the Society may be interested to know what percentage of them are actually doing work of this grade. Of those who have been at work, since their graduation from the Institute, for at least five years, 67 per cent. are at present in positions as foremen, or superintendents, or are in charge of construction departments, or in some corresponding positions where they are directing a considerable number of men in manufacturing plants. Of the remaining 33 per cent. a considerable number are in positions directly in line for positions of foremanship grade, and doubtless will in a short time be promoted into them. Of those who have been at work since graduation, from six months to four years, 25 per cent. are now holding foremanships or positions of similar grade; the balance being in positions of less importance.

THE USE, ABUSE, AND CARE OF LANTERN SLIDES.

BY HENRY H. NORRIS,

Professor of Electrical Engineering, Cornell University.

The subject of this paper is one of the many details which go to make up the routine of technical instruction. While not in itself of great importance, it bears a relation to pedagogical principles. The Society has not discussed the matter in any detail, and the writer takes pleasure, therefore, in relating his experience with the lantern slide collection of the electrical engineering department of Sibley College. As this collection has been examined with interest by a large number of teachers, several of whom have adopted the method used for filing and cataloguing, a description may save others some of the tedious experimenting which has resulted in the present plan.

In introducing the subject it may be well to consider some of the principles involved, and some of the dangers developed in the use of the projection lantern.

THE USE OF LANTERN SLIDES IN INSTRUCTION.

It is a well-known principle of teaching that impressions are conveyed much more readily through the eye than through the ear, hence the wise teacher utilizes visual instruction to a considerable extent. In teaching engineering, or any other subject, a large amount of raw material must be accumulated in the mind of the student before it can be organized. This raw material is preferably secured through observation. The opportunities for observation vary, and all students in a class cannot have seen the same things under similar conditions, nor can the members of the class be expected to have seen everything that is desirable as raw material for a given study. Pictures must supply this material to a certain extent, and such pictures will also serve to recall the impressions of earlier observations. By projecting such pictures upon a screen the teacher is able to point out the features of importance. From the student's standpoint, therefore, the projection lantern makes up for the deficiencies in his observation.

To the teacher the lantern provides a convenient means for directing attention to the objects upon which he wishes to base his instruction. He can assemble in a single hour a variety of illustrations drawn from all possible sources. These illustrations are in permanent form, and they may be used an indefinite number of times. The slides are comparatively inexpensive. When used with moderation they stimulate interest in the students, and hence make their work more enjoyable and efficient.

In using lantern illustrations the teacher must keep several important facts in mind. The contrasts of light and shade are trying to the student's eyes, hence he should not be expected to concentrate attention upon projected pictures for too long a period. The darkness of the room, combined with the eye strain, tends to produce sleepiness, particularly as a darkened room is usually poorly ventilated. This offsets to some extent the increase in interest due to the use of illustrations. Further, as the pictures remain before the students for a very short period, there is danger that the impression may be transient. This danger may be obviated by supplying the students with blue prints made from the negatives, and by emphasizing the particular points which the slide is intended to illustrate.

Abuse of Lantern Slides in Instruction.

Lantern slides are so easy to use that the teacher is apt to use them to excess. His lectures are liable to become mere descriptions and explanations of the illustrations, and they may become more of a hindrance than a help. The function of the illustrations is to stimulate the students to mental self-activity. Hence if the teacher does the thinking for the students, the latter may be mentally weakened rather than strengthened· There is also a danger of using too many slides at one time. The writer has attended lectures of an hour's duration, in which from seventy-five to one hundred slides were exhibited. Obviously no mind is so agile that it can adapt itself to so many fleeting impressions. For instruction purposes a very small number of illustrations should be used at one time. These illustrations should be a side issue rather than the main feature of a lecture or recitation. A whole hour should very seldom be given up to illustration. If possible students should be permitted to discuss the illustrations, so that their minds may be kept alert.

THE CARE OF LANTERN SLIDES.

In order to make the matter perfectly definite the plan in use in the department of electrical engineering at Sibley College will be described in some detail. The slides are made by a photographer located in one of the university buildings, who receives certain privileges, and in return does work for the departments of the university at very reasonable rates. The photographer files his negatives serially, the numbers being the same as those placed upon the slides by the department. With the slides the photographer supplies two or more blue prints made from the negatives, for use in cataloguing. On the "copy" supplied to the photographer is marked in lead pencil or ink the source of the illustration. By this means the student, on seeing the picture, is able to note its source, so that the original article may be consulted at leisure. The photographer also makes blue prints when such are ordered by the students, charging a nominal price for them.

The slides are filed in cabinets with a capacity of one thousand each, consisting of ten shelves, each containing one hundred compartments. These compartments are separated by thin tin partitions, the front edge of each being rolled over to prevent cutting of the paper binders on the slides. Each compartment is numbered, and the slides are filed serially, except where new slides replace the old ones which have been discarded. This system of filing has several advantages. As each compartment is supposed to contain a slide, a casual inspection shows when one is out. Further, as the slides do not rub against each other, the wear on the binders is very slight. The cabinets present a neat appearance, and compared with the value of the slides they are inexpensive. The cost of one cabinet is about twenty-five dollars, not including the numbering of the compartments.

In cataloguing the slides two indexes are used. One or more prints of each slide are mounted on large cards of press-board, twenty-five prints to the card. These cards are 14 × 17 inches in size. The prints are arranged by subjects, and the slides are cross-indexed to any desired extent. The advantage of the large card over the small ones frequently used is that the entire collection on any subject may be glanced over quickly. On each print is pasted a label, numbered to correspond with the compartment containing the slide. The large catalogue cards are separated into the natural divisions of the subject by means of loose boards with projecting indicators.

A serial index is also maintained for the purpose of recording the details connected with each slide. For each slide there is a 3 × 5 inch index card, and on it are entered the subject, the source, the date of ordering, the name of the person ordering, the negative number (which is usually the same as the slide number) and a brief description of what the slide shows and in what manner it can be used to the best purpose. This serial index has been found absolutely necessary, as many slides have been rendered useless because the teachers who ordered them have left, and there is great difficulty in finding out just what the slides are for.

The serial index is of great use in the annual inspection of the collection. The inspector goes over the blue print catalogue, and picks out the 3 × 5 card corresponding to each blue print. This card is then placed in the slide cabinet beside the corresponding slide. When all the blue prints have been checked there should be a 3 × 5 card in every slide compartment with a slide. If a compartment contains a card but no slide, the slide has been lost; if it contains a slide but no card, either the card was not made out at the proper time, or the slide was not indexed in the blue print catalogue. If the slide compartment is empty a slide has been destroyed, and it has not been replaced by a new one. If, on checking a blue print, a white card is not found for it, either the white card has already been placed in a compartment indicating a cross indexing of the slide, or the 3 × 5 card was not made out the proper time. As the purpose of this system is to make the working as nearly automatic as possible and as losses and mistakes will occur, the annual checking is very necessary in order to detect these losses and mistakes.

In the use of the collection the teachers pick out from the blue print catalogue the numbers of the slides which they wish. The lantern attendant selects the slides, returning them to the case immediately after the lecture. At first it was thought necessary to place in each vacant compartment a card containing the name of the teacher drawing out the slide. This has been found unnecessary, involving an additional operation. The loss of slides is small, and even when the loss can be traced to an individual he is rarely able to locate the missing slide.

By means of the system described it is always possible to select the slides for a lecture in from five to ten minutes; and practically no attention is required after each slide has been properly indexed.

SHOULD THE ENGINEER BE REQUIRED TO HOLD LICENSE?

BY WALTER H. DRANE, A.M.,

Dean of the Department of Engineering and Professor of Civil Engineering, University of Mississippi.

This question has been discussed in several engineering societies during recent years, and the author of this paper is not certain but that it has also been before this Society, but, so far as results are concerned, the question in every case seems to have been left in doubt. Bills, with this end in view, have been introduced in the legislatures of two of the western states, and probably also in others, but, for some reason, they have been all defeated. A bill, with the same purpose, drawn by the writer, has been introduced twice in the Mississippi Legislature, once in the House and once in the Senate, but each time it failed to pass even the committee to which it was referred. The chairman of the house committee, an honest, business-like farmer, informed the gentleman who introduced the bill, that it was the sense of the committee that engineering was a trade and not a profession, that not much educational training was necessary therefor and, in fact, that all the requisite knowledge could be picked up by anyone of average ability in a short while. By way of illustration, he cited himself as well versed in engineering, asserted that he had picked it up at odd times on the farm and could use the compass and chain about as well as any book-learned man. Hardly more intelligent recognition was accorded the measure in the Senate.

Before drafting his bill, the author wrote to several prominent practicing engineers and professors of engineering throughout the United States, asking their opinions as to the advisability of what the bill purposed, and though many favored the idea, there were some who did not, and for quite a variety of reasons, the most important of which will now be given.

From the practicing engineers, in substance, the reasons quite uniformly were that it would greatly hamper the practitioner, because, unlike the doctor and lawyer, his territory must necessarily be a wide one, covering at least two or three states, and the expense of keeping himself and all his assistants provided with licenses in all the states in which he might practice would not only be very troublesome but might be very great. The opinion was expressed also that, if one state required license and another did not, the effect would be to drive the engineers out of the state requiring the license into those which did not, thus, in large measure, depriving the state of the benefit of skilled service.

From the professors of engineering came the following reasons: (1) That it was unnecessary, as the dignity and efficiency of the engineering profession is not dependent upon recognition by the state. (2) That the state examinations would be necessarily very simple and therefore would afford very little guarantee of real ability. (3) That the engineering profession, though its work is based upon scientific knowledge, still requires, for its efficient practice, an experience which can not be acquired from books and, as a state examination, at most, would only show a book knowledge of elementary science, it would, for this additional reason, be a very poor test of fitness for the practice of engineering. (4) That, as the boards of examiners would be appointed by the governors of the states, there would be danger of involving the engineering profession in state politics and thus, instead of benefiting the profession, its efficiency might, and probably would, be lowered. (5) That it is not easy to define engineering and so there would be great difficulty in enforcing such a law, if, indeed, it should not prove to be practically impossible. (6) That it would very much hamper railroad work and could not be enforced upon United States government engineers. Hence it would interfere with industrial development in the one case and lead to confusion in the other. (7) That the engineering profession is a very broad one, including services of a widely diversified character, all of which has created many branches of the profession. This would necessitate that there be several kinds of engineering licenses, all having some things in common and yet widely separated as to others, and hence the scheme of licenses would be very complicated and would lead to much confusion and endless inaccuracies, which would destroy very largely the value of the licenses.

It is not the main purpose of this paper to combat these arguments, but to offer what appear to the writer to be some very good reasons why the engineer should be required to obtain license from the state, and then to leave the question open for discussion by this Society. For their criticism also will be given an outline of the bill drawn by the writer. With reference to these seven arguments against the plan, offered by the professors of engineering, it may be observed that, with two exceptions, Nos. 6 and 7, these same arguments might be, and doubtless some have been, advanced with equal force against requiring the lawyer, the doctor, the dentist, the pharmacist, and indeed any professional man to hold a license before being allowed to practice. These profesions require technical knowledge and are upon the same footing in that all perform services vitally affecting convenience, comfort, property, health, and life. Number 6 is without weight because a railroad simply would not employ an engineer in a given state unless he held license in that state, and the United States government engineers can be safely excepted from the operation of the law, as in other cases, since their being with the government is a sufficient guarantee of itself. Number 7 is an imaginary difficulty, as the examinations will of course cover only the essentials of an engineering education. There are as many different kinds of doctors as there are of engineers and no confusion or complexity exists in the state medical examinations.

All of these arguments are aside from the intent of the license plan. Its prime purpose is not to raise the standards of the engineering profession. It very probably would not have much influence in that direction, as it admittedly has not in the other professions, but it is to serve in some measure to protect the public from impostors who, as matters now are, can go where they are not known, claim to be engineers, and practice, or pretend to do so, without having even a rudimentary knowledge of the things they offer to do. The amount of faulty work done in all the states by such men and the amount of money squandered on account of them could hardly be estimated, and this is especially true in small towns throughout the country where local regulations are not enforced, and can not be, to protect the citizens, as is the case in the larger cities. It would seem, therefore, that simple economy should require that some step be taken to check, if not to put a stop to, so much wasteful humbuggery.

But there is a far more potent reason than mere economy. These men, for the sake of the money in sight, will shoulder any sort of responsibility and undertake the design and construction of anything, no matter how little they may know about it or how much the public welfare, human health and life may be dependent thereon. This phase of the question is, just now, of grave importance, and its importance is a growing one, for the reason that the small towns, in rapidly increasing numbers, are installing sewerage systems, water works, and electric light plants, besides other public utilities, upon all of which rests the convenience, health, and life of communities for long periods of time, if not permanently. The importance of having this work done and the operation of these plants supervised, if not economically, at least in a manner to protect health and life, is apparent to anyone.

As regards the promotion and the protection of public health, the physician and the engineer are enlisted in a common cause. But, with these money seeking impostors roaming throughout the country and underbidding those who can and who will perform competent service, the efforts of the physician and the engineer are largely nullified. It is an increasingly hopeless struggle to try to prevent typhoid fever, tuberculosis, and other zymotic diseases, especially in small towns, when disease-germ incubators and distributors are continually being constructed and maintained in the shape of poorly drained and filthy streets, faultily built and badly maintained sewerage systems and water supplies. This question is of great significance in the South where an immense amount of shoddy work is being done in the small municipalities and where ignorance of engineering runs riot. The typhoid fever problem is going to be a menacing one in the next ten or fifteen years, for a very large per cent. of the water works and sewerage systems will then begin fully to show the effects of faulty construction and poor operation. The great weight of this phase of the question will be fully appreciated when we reflect that the larger part of the population of the United States is resident in these small towns and the problem of public health, as affecting the majority, is one to be met very largely in these localities. While the cities usually have regulations for their own protection, these small communities are almost wholly without any protection of that kind and it is upon work in such places that incompetent men find employment.

The writer could fill a volume giving accounts of cases, illustrating the truth of these statements, which have come under his own observation, and doubtless other members of this Society can cite many more.

He will mention only one, that of a town of some three or four thousand inhabitants, a community of refinement and culture. In this town, the superintendent of the electric lighting, water works and sewers, was an illiterate old man who had moved in from a farm. The first new house he wired was connected directly to the street main without the intervention of a transformer. The house was saved only by the fact that he did take the precaution to put in a fuse. The systems of this town, costing at installation about $40,000, have seldom had any more intelligent supervision than this, and now, after only twelve years of use, the whole thing is being largely renewed, for which new bonds are being floated, although little provision for the liquidation of the original issue has been provided. How long this sort of thing can continue is a matter of conjecture. But this is not all. The engineer employed to draw the plans and write the specifications for this new installation, while a good machinist, has never even studied simple projection, and yet the whole outlay is entirely in his hands. All of this is typical of what is happening everywhere in the small towns, and particularly in the South. These things call loudly for a remedy and a preventative. Certainly the main function of the state is to guard the public welfare and to prevent, if possible, those things which jeopardize health, life and wealth. Surely then, in this case, the state should intervene and demand that a man, who would practice a profession like engineering, shall give evidence, even though it be small, that he possesses at least a little knowledge of what he proposes to do.

And again, though it may be admitted that the license requirement will in very small degree, if at all, affect the standards of the engineering profession, it will contribute very largely to the possible usefulness of the profession to others. The popular idea of a profession does affect, in large measure, the possibility of service accorded to it, and, so long as engineering is regarded as a mere trade, as it is by a large majority, and in the South by a very large majority, its work will not command the popular respect, nor will it receive at the hands of the law that recognition and protection which it deserves and which its importance demands. This part of the question would be relatively of small weight, if it were not for the fact that upon the engineer rests the public welfare, and whatever curtails his usefulness also vitally affects that. As long as the engineer is regarded as a tradesman, the preparation necessary for the performance of his work will never be demanded and will not be what it ought. This very misconception of the engineer's rank, with the consequent underrating of the importance of his work and the skill requisite therefor, is the source of the power of incompetence. Impostors can palm off their cheats on the public because the average man has never had a reason to consider the importance of engineering work, nor does he appreciate how vitally the prosperity of a community is affected thereby. And, even where some effort is made to insure competence, there is little recourse for reliable information. Applicants need little guarantee besides their own words and the easily gotten recommendations of their friends.

There is never any danger of incompetence getting in control of the larger enterprises, but, in this connection, it must not be forgotten that these constitute but a relatively small part of the services of the engineering profession. The great bulk of engineering work consists of small undertakings, which, because of their very smallness, as regards the amounts of money involved, are thought not to require so much skill. It is here that protection is needed, for it is upon such enterprises that incompetent men dare to offer their services with hope of success. Some inducement should be held out to those possessing real merit to undertake these works. But so great has cheap competition become that a real engineer can not afford to even offer to perform services individually small in magnitude, for simply being brought into competition with "shysters" will injure his reputation. If he would preserve his measure of popular respect he must reserve himself for the larger enterprises where such men do not dare compete. Thus the great bulk of engineering work is done by men of very little, if any, skill.

There is still another good reason for the license, in the effect it will have indirectly upon engineering education. While not doing much to raise the standards of collegiate training, yet in elevating the popular estimate of the profession, it will invite into its ranks more and more of intelligence and natural skill. In spite of the fact that the northern and western institutions are devoting much attention to engineering education, a statement not so true of the South, it is yet true that a larger part of the educational energy of the country is being expended in the training of the members of the other professions and into those professions is drifting a correspondingly larger part of the most intelligent young manhood. Engineering at best is an arduous profession, both in the preparation therefor and in its practice, and it is made less inviting to the average young man when he considers that, after all this preparation for a work which is in any case difficult, he will be forced to face competition with incompetency and with practically no protection therefrom. The writer believes that, with engineering licenses required all over the country, not only will the attendance in engineering colleges be increased very largely but, what is to be more desired, the grade of students will be much higher.

These are the reasons for the writer's belief that, like the lawyer and the doctor, the engineer should be required to hold a license upon examination before being allowed to practice. But the accomplishment of the passage of such a law by the states rests upon the engineers of the country. The lawyers and doctors are required to hold license because the members of those professions demanded that such a law be passed, and they see to its enforcement. If then the idea be a good one, both for the engineering profession as a whole and for the protection of the public, there is only one way to put the idea into an operative law, and that is for the members of the engineering profession to unite in a demand for its passage and enforcement in every state. The influence of this Society, composed as it is of most of the ablest and best known engineers of the country, will go far towards creating that demand.

The following is an outline of the bill as introduced in the Mississippi Legislature:

1. Requiring that all who would practice surveying or engineering in the State must obtain license to do so as provided in the bill.

2. Providing for the appointment by the governor of a board of five examiners, all of whom are to be practicing engineers of long standing and high reputation in the state. The members of the board are to hold office only with the governor appointing them and, after the first board has served, no one is to be eligible to appointment who does not hold an engineer's license. Members of the first board are to receive engineer's licenses upon going into office.

3. Organization of the board shall begin by electing a president and a secretary from among their number.

4. Records of all proceedings are to be kept by the secretary and such records are to be filed in the office of the secretary of state.

5. A fee of ten dollars is to be charged each applicant for admission to each examination he may take, whether successful or not, and the proceeds from these fees is to be divided equally among these members of the board present and holding the examination as their compensation therefor.

6. The examinations are to be held beginning Tuesday of the first week in April and October of each year and the board is to assemble for that purpose in the state capitol.

7. Three members of the board constitute a quorum for business and, in the absence of the president or secretary, a president or a secretary pro tempore must be elected.

8. The governor may remove, upon cause shown, any or all of the members of the board, and appoint others to fill their places, and he may fill any vacancies which may occur from other causes.

9. The state is to furnish all material, stationery, record

books, etc., necessary in the conduct of the examinations and in the keeping the records of the proceedings.

10. Providing for two grades of licenses, a surveyor's license and an engineer's license. The examination for the former is to be upon surveying instruments, plane surveying and particularly land surveying, including the history of public land surveys and the scheme therefor. The examination for the engineer's license is to include all the subjects required for the surveyor's license and in addition is to be upon such fundamental subjects as mechanics, hydraulics, masonry, frame structures, and roads. Experience also may be taken into account.

11. Providing that an engineer may practice surveying without being required to hold a surveyor's license in addition to the engineer's license, but that the surveyor shall not practice engineering until he has first obtained the license therefor by standing upon the subjects additional to those required for such license.

12. Requiring that each license shall be recorded in the office of the secretary of state within thirty days from the date of its issuance upon penalty of its becoming void after that date. A recording fee of one dollar is to be charged. Failing to have license recorded will necessitate the applicant's taking another examination in order to get license.

13. That when a license is destroyed or lost accidentally a new license may be issued in lieu thereof upon payment of twenty-five cents and having it recorded. No examination is required for reissuance.

14. Providing that, for a period of one year from the passage of the bill, licenses may be issued to those, either in the state or outside it, who apply in writing therefor and furnish also three sworn testimonials that they have successfully practiced surveying or engineering, as the case may be, for at least one year previous to the filing of the application. The license is to be issued to such upon payment of twenty-five cents.

15. Providing that no one shall be eligible to the office of

county surveyor, or to appointment as deputy thereof, or to appointment by any court or public official for the performance of any surveying work, who does not hold a surveyor's license. If appointment is to perform engineering work then appointee must hold engineer's license in order to be eligible.

16. Accompanying this bill was another to modify the code so as to include surveyors and engineers in the section providing penalties for practicing law, medicine, pharmacy, and dentistry without first obtaining license.

DISCUSSION.

PROFESSOR WOODWARD: Several years experience in the South leads me to believe that what has been said is very largely true. We cannot, however, feel that the remedy Professor Drane proposes will protect us from this effect. He stated in answer to inquiry that he would accept college diplomas in lieu of the license. Leaving entirely aside the matter of the ethical side of the question, it would seem that the college diploma would not always be a safe guarantee that the public would secure adequate services for its work. It would only insure that the man had a fundamental knowledge. A large proportion of the mistakes are not on account of ignorance of the underlying principles, but on account of lack of judgment in an effort to apply them properly; and I can hardly see how a license would do more to protect one from this defect than would a college diploma.

REPORT OF COMMITTEE ON INDUSTRIAL EDUCATION.

Prepared by Arthur L. Williston,
Secretary of the Committee.

At the Cleveland meeting of the Society the Committee on Industrial Education presented a descriptive report outlining a number of the more prominent forward movements in industrial education, and giving a brief sketch of the history of the formation and of the work of the National Society for the Promotion of Industrial Education.

After the report was received, by vote of the Society, the committee was continued with the request that it furnish for the annual meeting in 1908 a more detailed and statistical report. In compliance with this request the committee prepared a printed blank asking for most detailed information regarding day courses of study of vocational character which, with a circular letter of explanation, was sent to a large number of schools. From the replies to these inquiries that were received and from the published catalogues that accompanied them, the secretary of the committee has prepared the following report.

Report.

The great variety of types of schools to which circulars asking for information were sent, that are, to a greater or less extent, doing one kind of work or another in the field of education, has made it practically impossible to tabulate in any simple or systematic way, the data received—much of it being given in very considerable detail. It has seemed best, therefore, to attempt no general tabulation, but instead to group the schools together under a number of different headings according to the kind of work done by each; and then, to describe them separately or in groups according to the importance of their work in their special field. No attempt was made to include in this investigation industrial work for girls or for the colored race, or schools giving only courses of evening instruction. The impossibility of accurately determining the extent to which evening instruction was of truly vocational character has made it seem wise to the committee to confine its efforts in this report to day work alone. Therefore, evening classes and evening enrollments and schools giving only evening instruction will be referred to only in an incidental way.

Group 1.

Public Trade Schools.

At the present time there are but two schools in the United States forming a regular part of a public school system which may be properly called trade schools. These are:

The Milwaukee School of Trades, Milwaukee, Wis.
The Philadelphia Trades School, Philadelphia, Pa.

The Milwaukee School of Trades was founded in 1906 by a number of public-spirited men, as a private enterprise and under the auspices of the Manufacturers' Association, but was made a part of the public school system of Milwaukee on July 1, 1907. Its purpose is to give both practice and instruction in underlying principles of both the manufacturing and the building trades. The school does not hope to turn out journeyman mechanics, but, owing to the length and thoroughness of its courses, it is expected that the graduates will very rapidly develop into high-grade all-round skilled mechanics. The trades included are pattern making, machine work and tool making, carpentry and wood turning, plumbing, and gas fitting; and in addition to the shop practice in each of these trades there are trade lectures and practical shop talks, instruction in mechanical and free-hand drawing, workshop mathematics and trips of shop inspection. Approximately one quarter of the student's time during his course is devoted to academic instruction and the remaining three quarters are spent in shop practice. No boys under sixteen years are admitted, and a personal interview by the director and an examination or certificate of grammar school graduation are required for admission. The tuition is free, but the students are expected to pay from $4 to $5 per month for the material used.

The school has an excellent equipment and is doing excellent work. The shop for each course is equipped to accommodate about twenty-five men and the enrollment for 1908–09 is as follows:

	Day.	Evening.
Pattern making	31	23
Machinist	36	56
Plumbing	30	30
Wood working	15	19
Total	112	128

Evening courses are also offered in all of the above branches, as the table of enrollment indicates.

THE PHILADELPHIA TRADES SCHOOL was opened for the registration of students in September, 1906. It is a part of the public school system of Philadelphia and is conducted under the direction of a special committee of the Board of Public Education. The average age of the pupils is fifteen and one half years, and the majority of the boys enter the school directly from the public schools. No boy under fifteen years of age who has not graduated from grammar school, however, is admitted. Not over ten per cent. of those who enter have ever been employed in mechanical work of any kind after leaving public school before entering the trade school.

It is located in an old school building and is not yet thoroughly equipped, but improvements and additions are continually being made. The day courses are three years in length and include the following trades:

Carpentry.
Pattern making.
Electrical construction.
Mechanical drawing.
Architectural drawing.
Printing.

Evening courses are also offered in the following branches:

Bricklaying.
Plastering.
Plumbing.
Electrical wiring.
Sheet metal work.

Carpentry.
Pattern making.
House and sign painting.
Printing.
Mechanical drawing.
Architectural drawing.

The day courses devote about fifteen periods per week in each of the three years to shop practice; and the remaining twenty periods per week to mechanical drawing, practical mathematics and applied science, English language, history and economic history. The average enrollment for the year 1908–09 in the day classes is as follows:

Carpentry	5
Pattern making	19
Electrical construction	103
Mechanical drawing	28
Architectural drawing	22
Printing	17
Total day enrollment	194

The enrollment is divided among the three classes as follows:

First year class	106
Second year class	52
Third year class	26

In considering these figures it should be remembered that the entering class three years ago was very much smaller than the entering class for 1908. The total enrollment in the eleven evening classes is 476. The largest enrollment is in the plumbing and electrical construction classes, both of which number over 100 pupils.

Group 2.

Short Term Private Trade Schools.

There have been included in this group those schools whose sole or principal aim is to teach to beginners, through short day courses, mechanical trades, or enough thereof to enable the boys to get a start and remunerative employment in them. The number of well-established schools of this type in the United States is small. They are obliged to face the very serious economic difficulty that arises from the fact that the type of boys and young men who earn their living at mechanical trades are not able, except in very rare instances, to pay money for education or even to provide for their board and living expenses without some earning power, after they become old enough to begin to seriously learn a trade. They come from a class in society that expects boys after they are 14 years old to be a source of income to the family. To reduce this economic difficulty to the minimum the courses of instruction are made as short as possible.

The second problem which such a school must solve is to present instruction sufficiently practical on the vocational side to increase the boy's earning power immediately after leaving school, and also several years later, above what it would have been if he had started at work at the time that he entered school, to thoroughly repay him for both the time and the money sacrifice that he has made in order to attend school. The best known schools of this type are as follows:

The New York Trade School, New York City, N. Y.

Baron de Hirsh Trade School, New York City, N. Y.
Winona Technical Institute, Indianapolis, Ind.
David Rankin, Jr., School of Mechanical Trades, St. Louis, Mo.
Bliss Electrical School, Washington, D. C.
New York Electrical School, New York City, N. Y.
Artisan School, Syracuse, N. Y.
Coyne Trade Schools, New York City, St. Louis, Chicago, San Francisco, Boston and Cincinnati.

No attempt has been made to include here trade schools of this type for girls or young women, of which there are several good examples, such as:

The Manhattan Trade School for Girls.
The Chicago Industrial School for Girls.
Boston Trade School for Girls.

The New York Trade School was the first trade school of importance to be established in the United States. It was founded by Colonel Richard T. Auctmuty in 1881. Its purpose is to enable young men to get enough practice in mechanical trades—especially in the building trades—to enable them to get a good start, and at the same time to give them such principles of work as will awaken in them ambition to strive to become, with experience, thoroughly competent workmen. The courses of instruction are 17 weeks long, ranging from 30 to 34 hours per week, all of the instruction being of a practical character and given in the shops, with the exception of 3 or 4 hours per week work in mechanical drawing. The tuition averages about $40 per course of four months. The age required for admission is seventeen years.

The total enrollment in the day classes for the present year is 273, a decrease of 11 over the previous year. It is distributed as follows:

Plumbing	120
Electrical work	53
Bricklaying	23
Steam fitting	23
Carpentry	21
Cornice work	13
Sign painting	10
Fresco painting	6
House painting	4
Total	273

With the exception of carpentry, evening instruction is given in all of the above mentioned classes, and in addition there are evening classes in plastering, blacksmithing, pattern-making and printing. The total enrollment in evening classes is 642. The estimated annual expenditure is $60,000.

THE BARON DE HIRSH TRADE SCHOOL was established in 1884. Its object is to give to the children of recent Jewish immigrants a training that will enable them to earn their living in mechanical trades, in the shortest possible time, starting as advanced apprentices after leaving the school. All of the instruction is free, but the applicants must be sixteen years of age.

The term lasts five and one half months, and two separate classes are graduated each year, one in February and one in the middle of August. There are five trades taught:

The machinists' trade.
Carpentry.
Electrical work.
Plumbing.
Painting.

The capacity of the school is limited to 150 pupils, but many more than this number apply for admission each term. Besides the instruction in shop practice there is also given in all courses, instruction in figuring and estimating and in working from drawings. It is found that over three quarters of those who have graduated from the courses at the Baron de Hirsch Trade School are at present employed in the trades for which the school prepared them. The Baron de Hirsch Trade School offers no evening courses. The estimated annual expenditure is about $40,000.

WINONA TECHNICAL INSTITUTE was organized in 1904 and offers courses in the following trades:

Electric wiring.
House and sign painting.
Carpentry.
Tile setting.
Bricklaying.
Machine work.
Foundry practice.
Printing trades.
Lithography trades.

These courses vary in length from eight weeks to two years, according to the one selected, and also according to whether a full trade or a specialty is chosen. There were graduated from these trade courses in 1906, 65, in 1907, 91, and in 1908, 171. There were graduated from the printing trades alone in 1908 31 students, and 83 from the courses in the school of lithography.

The equipment and instruction in the printing and lithographic trades is especially excellent and complete. The course in foundry practice is also on an excellent basis. Owing to the commercial work that is done in this department, each student is enabled to earn $4.20 per week when putting in full time. This largely defrays his expenses.

David Rankin, Jr., School of Mechanical Arts although not yet in operation should, perhaps, be included in this group. It has recently been established in St. Louis with an endowment furnished by David Rankin, Jr., as its name indicates. The buildings are now completed and the principal and many of the instructors selected. It is planned to offer here, short practical courses in both the manufacturing and the building trades and it is hoped that it will be open for students in the fall of 1908.

The Bliss Electrical School offers a one-year practical course in electricity which is really of trade character, although more theoretical instruction is included in this course than is done in the courses of the schools previously mentioned. About 40 hours per week of work is required, from one quarter to one half of it being practical hand work. The school is supported entirely by tuitions which are $450 per year including board and room, or about $150 per year for tuition alone. The enrollment for the present year is 180, and it is estimated that about 750 students have graduated from this school since its organization.

New York Electrical School, located at 39 West Seventeenth Street, New York City, is a school of very much the same type as the Bliss Electrical School. It has quite an elaborate equipment and offers short practical courses in twelve different electrical trades.

There is no specified length of courses. The student is free to stay until he is satisfied that he has completed his trade. The courses are:

The installation of electrical bells, annunciators, batteries, etc.
Installation of telephone systems.
Installation of telegraph, fire and burglar alarm systems.
Installation and operation of dynamos and motors.
Street car control, lighting and heating.
Switch board installation.
Storage batteries.
Light and power wiring.
Electrical elevators.
High tension transmission lines.
Armature winding.

The school is supported entirely by tuition fees which are necessarily quite high compared with the length of the courses. In September, 1907, there were 172 pupils enrolled.

The Artisan School was recently organized in Syracuse by Professor John E. Sweet to train high grade machinists. It was started on a small scale with an equipment sufficient for twelve or fifteen boys. The school has had considerable trouble, owing, perhaps, to the thoroughness of the courses, in getting applicants. There never have been, up to the present time, more than ten or a dozen boys enrolled at once.

The Coyne Trade Schools offer very short courses in

Plumbing.

Bricklaying.
Plastering.
Electrical construction.
Stationary steam engineering.

These courses are intended to give just enough instruction to enable the students to get a foot-hold in the trade when times are good. The tuition is from $50 to $75 per course for which there is no definite limit of time, the student being permitted to remain until he has acquired a given degree of skill.

These schools are conducted for financial profit and it is a common impression that the courses are so short and the instruction so superficial that the student receives but little real benefit.

There are branches of these schools in New York, Chicago, San Francisco, St. Louis, Cincinnati and Boston. The largest enrollment in the New York School at any one time, for 1908 was about 300, but during the past twelve months about 800 were graduated.

The schools described above are the principal ones that belong in this group of short term private trade schools, but there should be included, also, to make the list complete a considerable number of special courses given in other institutions of different types such, for example, as the one-year trade courses in machine construction and in carpentry and building, in the School of Science and Technology at Pratt Institute, Brooklyn, N. Y., and certain short courses for apprentices in the Carnegie Technical Schools, and a number of smaller schools devoted to a single trade each, such as;

The Master Plumbers Trade School, of St. Louis, Mo., offering single trade courses in plumbing.

The North End Union, Boston, Mass., having a small, but excellent, day trade course for printing.

The St. Louis Trade School, offering a course in plumbing.

The Hawley School of Steam Engineering, giving short courses in stationary engineering for those who wish to obtain licenses as stationary engineers.

The automobile schools for training chauffeurs and others, conducted by the Young Men's Christian Association in Boston, New York City, and other places.

Group 3.

Long Course Private Trade Schools.

In this group belong those schools which offer courses three or four years in length. Many of them include with the instruction in shop practice, a larger proportion of academic or theoretical instruction than do the majority of the short term schools included in Group 2. And, as a rule, it is hoped that a considerable number of the graduates of these schools, because of the natural ability and intelligence of the boys who enter them, and because of the length and thoroughness of the courses and the opportunity for theoretical as well as practical instruction, will eventually rise to positions above the grade of the journeyman mechanic.

The best known schools in this group are the following:

The Williamson Free School of Mechanical Trades, Williamson School, Pa.
The Wilmerding School of Industrial Arts, San Francisco, Cal.
California School of Mechanical Arts, San Francisco, Cal.
Cogswell Polytechnic College, San Luis Obispo, Cal.
California Polytechnic School, San Luis Obispo, Cal.
Hebrew Technical Institute, New York City, N. Y.
Spring Garden Institute, Philadelphia, Pa.

THE WILLIAMSON FREE SCHOOL OF MECHANICAL TRADES was founded with an endowment of about $2,000,000, furnished by Isaiah V. Williamson in 1888. This school is somewhat unique in several particulars. It has a country location about fifteen miles from Philadelphia on a beautiful campus of over 230 acres. The boys attending the school are provided with homes in a number of small model cottages on the campus; and everything, instruction, home, board and clothing, is furnished free to the pupils. This makes it possible to hold the sons of parents having very limited means, of a type that are glad of the opportunity to learn a mechanical trade, in school for a full course of three years. The economic problem which faces most other trade schools is thus removed from Williamson Trade School by the conditions of its endowment. The length of the courses makes it possible to give the most thorough instruction in both the principles and the practice of the trades. The trades taught are:

Carpentry.
Bricklaying.

Machine work.
Pattern making.
Care and operation of steam and electrical machinery.

Each pupil takes up but one trade, but is taught in addition, reading, writing, grammar, geography, arithmetic and the essentials of algebra, geometry and trigonometry, elementary science and some principles of applied science. The school shops are run eight hours per day every day except Saturday, and a half day on Saturday. Each pupil devotes about one half of his time to class work and the other half to shop practice. Great stress is laid on the development of intelligence and character, and it is the aim of the school to train first class all-around mechanics who will have a high sense of responsibility, and who also will be both loyal and ambitious workmen, and good and intelligent citizens. The capacity of the school is at the present time about 240, and between October, 1891, when the first class was received, and March 30, 1907, 599 pupils have been graduated, as follows:

Bricklayers	143
Carpenters	121
Stationary engineers	52
Machinists	170
Pattern makers	113
Total	599

The school has been obliged to turn away many more applicants than it could accept because of the demand for its instruction and its limited capacity. The statistics gathered show that the graduates receive full journeymen's wages within a comparatively few months after graduation, and not infrequently immediately after graduation. The estimated annual expenditure is about $100,000.

THE WILMERDING SCHOOL OF INDUSTRIAL ARTS was founded in 1894 through a bequest of $400,000 left to the regents of the University of California for the purpose of establishing a school *"to teach boys trades fitting them to make a living with their hands, with a little study and plenty of work."* The first class was admitted in January, 1900. The full course is four years in length, and upon graduation it is expected that the boy will be able to obtain employment as a skilled journeyman mechanic. The trades taught are:

Carpentry.
Plumbing.
Cabinet making.
Electrical work.
Bricklaying.
Blacksmithing.
Architectural drawing.

A boy may begin an apprenticeship when he enters the school, or he may defer the selection of a trade for two years. When he selects his trade he devotes his entire shop time to the single trade. If he defers the selection of his trade, his preliminary course must include the regular academic subjects and not more than two industrial branches at any one time. He may change, however, from one industrial department to another at the beginning of a new term, provided he has shown proper effort. The academic instruction includes architectural drawing, writing, reading, composition, history and literature, and the usual high school branches of mathematics and science.

The enrollment is limited to 200 boys, and admission is limited to graduates of a grammar school or to boys over 16 years of age who are within one year of graduation. The enrollment for the year 1907–08 was 220 pupils, distributed as follows:

Carpentry	35
Plumbing	35
Cabinet making	30
Electrical work	50
Bricklaying	35
Blacksmithing	5
Architectural drawing	30
Total	220

The estimated number of graduates from each of the courses since their establishment is as follows:

Carpentry	20
Plumbing	15
Cabinet making	15
Electrical work.*	
Bricklaying	15
Blacksmithing	8
Architectural drawing	25
Total	98

The number of diplomas and certificates granted during the past year was 16. The number of graduates is comparatively small compared with the enrollment due in a large measure to the high wage scale prevailing in the community which tempts boys to drop out of school and seek employment before graduation, and also to the fact that the American school system is not properly graded to meet the requirements of trade education in a school of secondary grade. The boy who completes the grammar school and enters a school of high school grade is not, except

* This course was established in 1905.

in rare instances, the type of boy who will earn his living in mechanical trades.

It is estimated that 80 per cent. of the graduates of the Wilmerding School are at present employed in the trades for which their courses of instruction prepared them. There is no charge for tuition. The estimated annual expenditure is $22,000.

The California School of Mechanical Arts was established in 1895. It is located on a piece of land adjoining the Wilmerding School, and gives instruction in manufacturing trades, supplementing the building trades taught in the other school. The courses are four years long, the first three years being devoted to a preliminary course which is essentially the same as the courses given in the so-called manual training schools, all boys being required to take general woodwork, pattern making, molding, forging and machine shop practice, in addition to the usual academic subjects, before specializing in any trade. In the fourth year the boys may elect any one of the folowing trades:

Pattern making.
Forging.
Molding.
Machine shop practice.
Mechanical drawing.
Industrial chemistry.
Preparatory courses for technical colleges.
Polytechnic courses.

There are about 400 boys enrolled in the entire school, 43 being in the fourth year in the trade courses, as follows:

Pattern making	6
Forging	5
Molding	0
Machine work	12
Mechanical drawing	10
Industrial chemistry	10
Total	43

Since the establishment of these courses in 1895 the estimated number of graduates from them is as follows:

Pattern making	30
Forging	15
Molding	0
Machine work	60
Mechanical drawing	50
Industrial chemistry	20
Total	175

The enrollment in the college preparatory courses and in the polytechnic course which are offered in this school has increased at the expense of the trade courses. The principal reports that "students will not attend secondary schools for the purpose of acquiring trades unless the amount of academic work is reduced far below the amount required in the ordinary high school, or even in the manual training high schools. "Furthermore," he says, "we have had to restrict our enrollment by means of competitive examinations which tend to eliminate boys who would be most likely to want trades." The California School of Mechanic Arts also offers practical courses in cooking, dressmaking and millinery for girls, similar to the trade courses for boys, and has an enrollment of about five hundred girls. The tuition is free. The estimated annual expenditure of the school is $27,000.

COGSWELL POLYTECHNIC COLLEGE is a school of somewhat similar type to the California School of Mechanic Arts. It was founded in 1888, and admits boys who have completed the eighth grade in the public schools, and offers to them for the first two years a general preparatory course similar to the first two years of a manual training high school, with the exception of the fact that the time is about evenly divided between academic work and industrial work. This is followed by two-year trade courses in which the student specializes in a single trade and devotes a large proportion of his time to trade work. The courses offered are as follows:

Machine drawing.
Electrical design and construction.
Pattern making.
Machine shop practice.
Industrial chemistry and assaying.

In the first four of these courses 30 hours per week are devoted to shop or practical hand instruction. The enrollment in all courses for the year 1907–08 is 234, and the enrollment in the last two years in the trade branches is as follows:

Machine drawing	32
Electrical design and construction	11
Pattern making	3
Machine shop practice	32
Industrial chemistry and assaying	4
Total	82

There are also three similar practical courses for girls in which there were last year 94 enrolled in the last two years of the courses. No tuition is charged for any of the courses.

The California Polytechnic School is a state institution, located at San Luis Obispo, Cal., which was established by Act of the Legislature in 1901. It offers a considerable variety of practical courses for boys and girls in agriculture, mechanical trades, and household arts. It requires a certificate of graduation from the eighth grade of a grammar school for admission, and offers courses three years in length in which the time is about equally divided between practical work in shop or laboratory and class room instruction. The mechanical trades included are:

Carpentry.
Forging.
Machine work.
Steam and electrical machinery.
Mechanical drawing.
Surveying.

The reported enrollment for 1907–08 in these classes is as follows:

Carpentry	46
Forging	65
Machine work	30
Steam and electrical machinery	42
Mechanical drawing	20
Surveying	12
Total	215

Considerable allowance, however, should be made for names counted twice in the above enrollment as the total enrollment for the school was about 141; and the total number of graduates since the school was opened in 1903 is but 40. No tuition is charged for any of the courses, and the estimated annual expenditure is about $40,000.

The Hebrew Technical School was established in New York City in 1883. It is supported by contributions from members of the Hebrew Technical Institute Society. The length of the courses is three years, and the pupils must be residents of New York City, at least twelve and one half years of age, and pass an entrance examination in English, geography, arithmetic and United States history. The course for the first two years includes the usual school branches and manual training. In the third year there is opportunity for electing one of the following trades:

Wood working.
Machine work.
Instrument making.
Practical electricity.
Mechanical drawing.

At the last graduation, May 13, 1908, the following numbers were graduated:

Wood working	7
Machine work	17
Instrument making	13
Practical electricity	19
Mechanical drawing	22
Total	78

The enrollment in the day classes was as follows:

First year classes	90
Second year classes	97
Third year classes	85
Special	2
Total	274

But 10 per cent. of the pupils are of American parentage, 44 per cent. are of Russian parentage. On the other hand, 72 per cent. of the boys are born in the United States. A very small percentage of their fathers are engaged in mechanical trades. Nearly one third of them are in the clothing and tailoring trades, and the majority of the balance are engaged, on a small scale, in commercial pursuits.

The total number of graduates since the school was organized is 805. Of the 780 who are still living, 694 have recently been heard from. Seventy-five per cent. of these are following mechanical trades, as follows:

Pattern makers and wood workers	32
Machinist and metal workers	39
Electricians, employees in electrical houses and electrical contractors	126
Draughtsmen and designers	133
Architects and engineers	35
General mechanics	44
Foremen and superintendents	67
Manufacturers	8
Teachers and students	39
Clerks, salesmen, bookkeepers, etc	150
Physicians, pharmacists and lawyers	21
Addresses unknown	66
Unemployed	20

The average weekly earning of those employed in mechanical trades is as follows:

Class of 1907	$10.25
Class of 1905	17.00
Class of 1900	28.00
Class of 1895	39.00

THE SPRING GARDEN INSTITUTE of Philadelphia offers three-year day courses in:

Mechanical drawing.
Metal work.
Wood working.
Applied electricity.

In these departments the students receive instruction in drawing, mathematics, nature of materials as well as in shop practice. The purpose is to train mechanics and at the same time give them such a thorough foundation that they will be likely with experience to advance to higher grades.

The enrollment in the first-year classes is limited to 100. The total enrollment in the three classes is not far from 150 pupils.

It is somewhat doubtful whether four of the schools included in this group, The Wilmerding School of Industrial Arts, The California School of Mechanical Arts, Cogswell Polytechnic College, and the California Polytechnic School, should be classified as trade schools, although this aim is distinctly set forth in their catalogues. The training which they offer includes so much instruction in academic branches, science and mechanical drawing that they attract boys whose ambition is for more responsible positions than those of journeyman mechanics. Those who are willing to devote four years to instruction of this type, and who complete these courses do so as a rule with the hope of entering the skilled trades under especially advantageous conditions and rapidly advance into position of foremen, inspectors, designers, etc.

GROUP 4.

Institutional Trade Schools.

There are several examples of excellent trade schools which are conducted as a part of other institutions, the best known examples of which are:

Girard College, Philadelphia, Pa., an institution founded in 1848 for the education of orphan boys.
The Miller School of Albermarle, Va., founded in 1878 for orphan boys and girls.

Girard College admits boys between the ages of six and nine, who are graduated at from sixteen to eighteen years of age. The pupils are supported and educated entirely without charge. The total enrollment of the school is between 1,600 and 1,700.

In 1902 trade courses were organized in which those boys who so desire can spend their last two years, devoting four hours a day, or 24 hours per week, to the special department. These trade courses are proceeded by a preparatory course in which there is a comparatively small amount of mechanical instruction in a variety of different trades. The trade courses represented are:

Carpentry.
Pattern making.
Forging.
Foundry work.
Machine work.
Electrical construction.

Considering the age of the boys and the way in which they are selected, this school is doing a work of very unusual excellence. About 1,200 of the boys receive instruction in mechanical trades and in the preparatory manual training. The annual expense of this department is from $18,000 to $20,000.

The Miller School of Albermarle, at Crozet, Va., was established in 1878 for orphan children who are admitted between the ages of twelve and sixteen years of age, and who are clothed, fed and housed, and provided instruction in the English branches, agriculture and the mechanic arts, free of expense for a period of from four to eight years, according to the age at which they are admitted.

The mechanical courses included are:

Carpentry.
Cabinet making.
Machine work.
Forge work.
Foundry work.
Printing.
Care and operation of steam and electrical plants.
Painting.
Plumbing.
Mechanical drawing.

All of the pupils are required to take the full academic course in addition to the practical instruction and for this reason, and also probably because of the length of the courses, a comparatively small proportion of those who enter are graduated. Since the school was organized about 1,000 pupils have been enrolled. The majority of these have remained in the school from four to seven years. Those who have gone out from the school have found a great variety of mechanical and non-mechanical employments. The largest number, in any one occupation, however, are machinists; and between 25 and 30 have become teachers of manual training and similar subjects. The annual expenses are between $70,000 and $80,000.

GROUP 5.

Public Secondary Industrial Schools.

There are at least three public secondary schools that should be referred to in this report. These are:

The Secondary Industrial School of Columbus, Ga.
The Technical High School of Cleveland, Ohio.
The Cooperative Course of the Fitchburg High School.

In THE SECONDARY INDUSTRIAL SCHOOL of Columbus, Ga., the pupils are taught the mechanic arts and textile trades including:

Machine work.
Foundry work.
Carpentry.
Pattern making.
Textile trades.

The textile trades are taught in rooms completely equipped as a cotton and hosiery mill, and the instruction includes all operations in cotton from the picker through to the finished product on the fancy looms. The announcement of the school states: "The aim of the Secondary Industrial School is to prepare young men of Columbus and vicinity for service as bread winners of good earning power."

The second paragraph starts, "it is a trade school." No foreign languages are taught, and while English, mathematics, history and science, are included, three fifths of the time in the course has been given over to industrial work. There is no general course. The courses preparatory to the different trades are entirely distinct and separate from the start. All of the courses are three years in length. The total enrollment for 1908 is 105 pupils.

The Cleveland Technical High School has just been completed and will open its doors to pupils next September (1908). It offers a four year course. One third of the time in the first three years and one half of the time in the fourth year is devoted to industrial instruction. Foreign language instruction has been practically eliminated from the course, and all of the instruction in English, history, mathematics and science is made to relate as closely as possible to the instruction in the practical branches. The following is a quotation from the latest prospectus:

"The Cleveland Technical High School has two immediate ends in view: (1) to prepare youth of both sexes for a definite vocation and for efficient industrial citizenship; (2) to help men and women already engaged in a vocation to better their condition by increasing their technical knowledge and skill."

The school is planned for an entering class of about 600 pupils.

The City of Fitchburg is about to open next fall a Cooperative Half-time Course in which the public high school of the city and a number of local manufacturers will cooperate in very much the same way that the University of Cincinnati and the local manufacturers of Cincinnati are cooperating. The plan will be similar to the one which Dean Schneider described in his paper given before this Society a year ago, on a "Six Year Cooperative Engineering Course," and in the paper which he is presenting to us at this meeting.

Perhaps, also, there should be included in this group the technical high school recently established at Altoona, Pa., which was referred to in the report of this committee presented a year ago.

Group 6.

Public Preparatory Trade Schools.

At the present time there are no public schools which offer strictly vocational training to boys of fourteen, fifteen or sixteen years of age, or to boys who have not graduated from grammar schools. It should be noted, however, that there are several cities, notably New York, Rochester, Boston, Utica, Albany and Syracuse, that are seriously considering the establishment of such schools, and it is probable that before the end of another year several such schools will be in actual operation.

Group 7.

Secondary Technical Schools.

This group includes those schools which offer courses of instruction intended to train young men for such positions as foremen, master mechanics, inspectors, etc., and for similar positions between the grade of skilled mechanics and engineers. The best known schools of this type are:

The School of Science and Technology, Pratt Institute, Brooklyn, N. Y.

Lewis Institute, Chicago, Ill.

Drexel Institute, Philadelphia, Pa.

The Regular Day Industrial Course in the School for Apprentices and Journeymen of the Carnegie Technical Schools, Pittsburg, Pa.

Mechanics Institute, Rochester, N. Y.

The Ohio Mechanics Institute, Cincinnati, O.

Webb's Academy and Home for Shipbuilders.

The distinctive features of the courses included in this group are that, as a rule, they give practical instruction in more than one trade, and also give applied science and technical instruction of a grade considerably in advance of that usually given in technical high schools.

THE SCHOOL OF SCIENCE AND TECHNOLOGY of PRATT INSTITUTE is the department which includes all of the technical and trade work for men. This department of the institute was established in 1887. It offers three two-year courses of foremanship grade for those who wish to enter electrical, mechanical or chemical manufacturing.

First. *Applied Electricity,* for inspectors, testers and detailed designers for companies manufacturing electrical machinery and apparatus; cable testers, inspectors, etc., for the telephone companies, and similar positions for electrical railways and operating companies supplying light and power.

Second. *Steam and Machine Design,* for power plant operators, designers, inspectors and foremen in manufacturing plants.

Third. *Applied Chemistry* for foremen, assistant superintendents, inspectors, mixers and testers in chemical manufacturing plants.

The majority of those entering these courses are mature and have had practical experience before they come to the Institute. They are, therefore, able to obtain, after completing their courses, positions of responsibility. The enrollment in the school for the year 1907–08 was as follows:

School of Science and Technology, Pratt Institute.

Day Foremanship Courses—Two Years.		
Applied Electricity	129	
Steam and Machine Design	123	
Applied Chemistry	53	305
Day Trade Courses—One Year.		
Machine Construction	38	
Carpentry and Building	23	61
Total in day courses		366
Evening Enrollment.		
Evening technical classes	560	
Evening trade classes	268	
Total evening enrollment		828
Grand total		1,194

Lewis Institute is properly included in the group of secondary technical schools although the regular courses of instruction for which it offers its certificate and degrees are as follows:

A four-year academic or college preparatory curriculum.

A college course of instruction leading to the title "Associate in Arts."

A four-year college curriculum leading to the degree of mechanical engineer.

A course leading to the title of "Associate in Domestic Economy."

The institute was opened in September, 1896, and up to July, 1907, it had granted 774 degrees and certificates. Ten times as many students have attended who have never received a formal certificate, however, and these have probably received as large returns in proportion to the time and money invested, as the certificate holders. Many of them have been attracted to Lewis Institute because of the shops and laboratories and the excellent mechanical and applied science instruction. For them the director has been always willing to plan excellent courses to fit their individual needs, and while no course of secondary technical training is listed in the catalogue, it is probable that a much larger number of boys have received instruction of this grade at Lewis Institute than have ever completed the engineering courses. It is, however, impossible to obtain statistics on this point, or to tell how many such are at present enrolled. At the present time 200 boys are enrolled in the various shops, taking on an average about ten hours per week.

The total enrollment in the evening classes is about 1,200.

Some of the courses offered by DREXEL INSTITUTE are also best classified in this group. Drexel Institute offers a three-year course in Architecture, and also three-year courses leading to diplomas in electrical engineering, mechanical engineering and civil engineering.

Besides these more advanced courses, however, it also offers a three-year elementary technical course in mechanic arts; a two-year course in mechanical drawing and a two-year course in machine construction. In these three last-named courses about one half of the time is devoted to practical instruction in shop work and mechanical drawing, and the remainder of the time to English branches, mathematics and applied science.

THE MECHANICS INSTITUTE of Rochester offers certain courses in mechanic arts which are properly included in this group. These courses are intended to take students with a grammar school education or its equivalent and fit them in three years for such positions as mechanical draughtsmen, electrical workers, inspectors, etc., and for other positions in manufacturing establishments that offer good prospects of ultimate advancement. These courses are three years in length and give practical instruction in several trades. The courses are as follows:

Mechanical course in mechanic arts.
Electrical course in mechanic arts.

In each one of these courses mathematics is continued five times a week throughout the three years. English is taught throughout every year, five or six times a week. Mechanical drawing is given six times a week for three years in the mechanical course, and for the first year in the electrical course. Shop work including joinery, wood-turning, pattern making, forging and machine shop practice is given from eight to ten periods a week. Elementary science and applied science with practical laboratory instruction is given from three to sixteen hours per week according to the year and the course. The tuition for these courses is seventy-five dollars per year. Enrollment for year 1908–09 is as follows:

First year	24
Second year	86
Third year	24
Specials	25
Total	159

The Mechanics Institute of Rochester also offers courses in normal manual training, in domestic science and art, and in fine and applied arts. It offers evening classes in all of these branches and also evening technical and evening trade classes. The total individual enrollment in the year 1906–07 was 3,190. The total enrollment in evening trade and evening technical classes was 822.

THE OHIO MECHANICS INSTITUTE of Cincinnati has been in operation for eighty years. Its purpose is the general advancement of the mechanical arts and the development of technical education, largely through the work shops and laboratories. The catalogue states "The Ohio Mechanics Institute lays special stress upon vocational training."

There are four four-year courses to which graduates of a grammar school are admitted. These courses are somewhat similar to the courses of a four-year manual training high school with the following exceptions: very little time is given to foreign languages, and the work is more definite and specialized, aiming to prepare students for specific places in practical work, and there is much more advanced technical work than is found in four-year manual training high school courses. The courses are as follows:

Course in mechanics.
Course in architecture.
Course in science.
Course in industrial art and design.

The tuition is from $40 to $50 per year. The enrollment in the day classes is as follows:

First year	93
Second year	78

Third year	60
Fourth year	32
Special students	108
Total	371

Webb's Academy and Home for Shipbuilders owes its origin to William H. Webb, a naval architect and shipbuilder, who established at Fordham Heights, New York City, on the banks of the Harlem River, Webb's Academy. The building was completed in 1894. The requirements for admission are that an applicant shall be American born and that his parents shall be unable to provide for his education. The age requirements are from fifteen to twenty years. A competitive examination is required. No charge is made for tuition. The course of study extends over three years and includes algebra and such operations of plane and solid geometry and trigonometry and elementary calculus as find practical application in the art of shipbuilding. Considerable theoretical instruction is given in marine engineering. A large amount of time is devoted to mechanical drawing and elementary naval architecture. There is no shop work included in the course, but in order that the students may acquire practical knowledge they are required to spend about eight weeks of their summer vacations in various shipyards throughout the country. There were 30 students enrolled in this school during the year 1907–08, and since its establishment in 1894, 106 have been graduated. Twelve were graduated during the last twelve months. The estimated annual expenses are $1,500.

GROUP 8.

Textile Schools.

In this group of industrial schools there should be mentioned the following:

The Philadelphia Textile School, Philadelphia, Pa.
Lowell Textile School, Lowell, Mass.
The New Bedford Textile School, New Bedford, Mass.
The Bradford Durfee Textile School, Fall River, Mass.
Ludlow Textile School, Ludlow, Mass.

THE PHILADELPHIA TEXTILE SCHOOL, which is a branch of the Pennsylvania Museum and School of Industrial Art, was opened in the year 1877–78. It has an elaborate equipment and gives the most thorough and practical kind of instruction in the textile art and trades. The following courses are offered:

Regular course	three years.
Cotton course	two years.
Wool and worsted course	two years.
Silk course	two years.
Jacquard design course	two years.
Yarn manufacturing course	two years.
Chemistry, dyeing and printing	two years.

The aim is to graduate men who will be competent to become superintendents of textile establishments, including dyeing, printing and finishing. All of the instruction is of the most practical character and is given in laboratory or mill departments. No academic instruction is included. The enrollment for the present year is 105 in the textile departments of the day classes.

The estimated total enrollment in day and evening classes in the textile school and in the school of applied art is about 2,500.

The Lowell Textile School has a magnificent equipment for textile instruction, the estimated value of which is over $200,000. Some idea of this can be obtained from the following statement of floor space devoted to its several departments:

	sq ft.
Cotton spinning and knitting	12,000
Wool and worsted spinning	20,700
Decorative art and textile design	12,400
General chemistry and dyeing laboratories	14,000
Commercial dyeing	4,570
Industrial chemistry	1,572
Finishing rooms	7,000
Power weaver	15,600
Mechanical and electrical engineering	13,600

The school offers five regular courses. They are as follows:

Cotton manufacturing.
Wool manufacturing.
Textile design.
Chemistry and dyeing.
Textile engineering.

All of these courses are three years in length. The enrollment is:

Day students	177
Evening students	539
Total	716
Names counted twice	47
Net total	669

The New Bedford Textile School of New Bedford, Mass., was opened for instruction in October, 1899. The school occupies a fine brick building with a floor space of 46,000 square feet. It has an excellent equipment and offers practical instruction in both day and evening classes. The day courses are as follows:

Complete manufacturing course	three years.
Cotton carding and spinning course	one year.
Weaving course	one year.
Designing course	two years.
Chemistry and dyeing course	two years.
Complete knitting course	three years.

The greater part of the instruction given, however, is at night. The enrollment for the year 1906–07 was as follows:

Day classes	26
Evening classes	433
Total	459

THE BRADFORD DURFEE TEXTILE SCHOOL, Fall River, Mass., was opened for students in March, 1904. It is housed in a large, well lighted building and is equipped with a great variety of machinery. Three courses are offered, as follows:

Design and weaving	two years.
Chemistry and dyeing	two years.
General cotton manufacturing	three years.

Most of the instruction given by the school, however, is evening instruction, there being only about ten or a dozen day students enrolled this year.

The number of evening students who attended the entire school year was 226.

THE TEXTILE SCHOOL at Ludlow, Mass., was but recently established and no statistics are yet available. The plan of its organization is that of a *"half-time"* school, in which the school and the local manufacturers cooperate on a basis somewhat similar to the plan of the University of Cincinnati.

There should also be mentioned the textile schools giving evening instruction in Lawrence, Mass., North Adams, Mass., and also the departments of textile engineering in Clemson Agricultural College, Clemson College, South Carolina, and in the Georgia School of Technology, Atlanta, Ga.

Note.—A report on the textile schools of Massachusetts has been prepared by the Massachusetts Commission on Industrial Education.

GROUP 9.

Schools of Horology and Watch Making.

There are a number of small schools in the United States devoted to horology or watch-making and jewelry. The more important ones are:

The Department of Horology, Bradley Polytechnic Institute, Peoria, Ill.
The Waltham Horological School, Waltham, Mass.
Hutchinson's School for Watch-makers, Engravers and Opticians, Laporte, Ind.
Woodcock's Watchmaking and Engraving School, Winona.
St. Louis Watch-making School, St. Louis, Mo.
Omaha Watch Repairing, Engraving and Optical Institute, Omaha, Neb.
Jewelers' School of Engraving, Chicago, Ill.

The horology department of Bradley Polytechnic Institute was started in 1886 and became a part of the Bradley Polytechnic Institute in 1897. It occupies an entire building with an excellent equipment. Instruction is individual, except in optics and drawing, where classes are formed every three months. The length of the course as a rule depends on the progress of the pupil. The complete course, however, is three years. The enrollment is as follows:

Watch-making	80
Engraving	30
Jewelry	25
Optics	50
Total enrollment for year	281
Approximate number of graduates since 1886	3,000

The other schools of this type are, as a rule, small and are conducted by one, two or three instructors. The Waltham Horological School is next in importance. It was established in 1870.

GROUP 10.

Miscellaneous Day Trade Schools.

There are a number of special trade schools not included in any of the above groups, such, for example, as trade schools for brewers, for barbers, for garment cutters, schools of telegraphy, schools of photography, etc. A number of these are well established and are doing a useful work. There are, for example, at least four brewers schools. The United States Academy of New York, which charges a tuition of $500 to those who have already had considerable experience, for the purpose of turning out master brewers. This school has five instructors, three of whom are college graduates, and from thirty to forty pupils. Thirteen were graduated during the last year, and 750 have been graduated since the school was organized. The equipment is quite elaborate.

There should also be mentioned the National Brewers' Academy of New York, The American Brewing Academy of Chicago and Hantke's Brewers' School of Milwaukee. It is not necessary to describe the remaining schools in this group.

No attempt has been made to include in this report, Industrial Schools for Colored Boys and Young Men, many of which are doing most excellent work, for example, the Tuskegee Institute of Tuskegee, Alabama, which has a large variety of trade departments, and 1,169 students in 24 different trades; the Armstrong and Slater Memorial Trade School of Hampton, Va., with 249 students in 12 trades; and upwards of two dozen other schools doing the same kind of work on a smaller and less important scale.

GROUP 11.

Evening Industrial Institutes.

While no attempt has been made to include evening instruction in this report, it would not be complete without making some reference to the magnificent work done in trade and elementary technical classes by such schools as Cooper Union of New York, which provides for, in addition to the day classes in engineering, evening instruction for over 2,000 students annually; the Mechanics and Tradesman Institute of New York which has an evening enrollment of nearly 2,000; the Franklin Union of Boston which was recently organized and already has an enrollment of over 500; the evening classes of Pratt Institute of Brooklyn, the Drexel Institute of Philadelphia, the Mechanics Institute of Rochester, Spring Garden Institute of Philadelphia, The Ohio Mechanics Institute of Cincinnati, which have already been referred to; the Wells Memorial Institute of Boston, The Virginia Mechanics Institute of Richmond, Va., the Newark Technical School, Newark, N. J., the Lowell Technical School for Industrial Foremen, of Boston, The Casino Technical Night School of East Pittsburg, The Massachusetts Charitable Mechanics Association Evening Trade School (which is devoted entirely to shop instruction in the building trades), The Franklin Institute of Philadelphia, the evening schools conducted by many cities, such as New York, Brooklyn, Springfield, Mass., the evening classes conducted by the Massachusetts Commission on Industrial Education, etc.

GROUP 12.

Young Men's Christian Associations and Young Men's Christian Union.

It is difficult to estimate just how much of the educational work of the Young Men's Christian Associations and the Young Men's Christian Union is vocational, and how much of it is more accurately described as general education. For a number of years past, however, a larger and larger proportion of the work has been of a practical character, and, therefore, it should at least be referred to in this report. The extent of this work can be judged from the fact that in the year 1907, over 72,000 students attended regular classes in 385 different associations for an average of 52 hours, and with an average percentage of attendance of 73 per cent. And these students contributed over $268,000 in fees during the year. Ten years before the income from such tuitions was but $18,000, and the increase of $250,000 during these ten years has been possible largely, because more and more of the instruction has been of such a character that it would increase the earning power of men who attended, and has, consequently, appealed to them as a good investment. The Associations in 19 different cities report over 500 students each and New York (West Side) reports 1,898, Boston 1,802, Chicago 1,776, New York (23d Street) 1,413. The Young Men's Christian Union of Boston reports 1,158 students in 19 subjects and 28 classes.

The schools referred to under the various headings of this report include all of the larger and more important ones in the United States in the field of Industrial Education having day classes for white boys and young men. Not all of the blanks sent out, however, were returned and some of the smaller schools have been necessarily omitted because of lack of definite data. It is hoped that such omissions are few and comparatively unimportant. The committee will welcome any additions or corrections to this report in order that it may keep its records accurate and complete.

C. M. Woodward,
Henry T. Eddy,
G. F. Swain,
G. A. Goodenough,
A. L. Williston,
W. B. Russell,
Committee.

REPORT OF COMMITTEE ON NECROLOGY.

CHARLES SCOTT MAGOWAN,

Late Professor and Head of the Department of Municipal and
Sanitary Engineering, College of Applied Science,
The State University of Iowa.

Charles Scott Magowan was born in Fairfield, Iowa, December 1, 1858. He entered the State University of Iowa with the class of 1883, but, remaining out of school one year engaged with the Chicago, Milwaukee and St. Paul Railway, he graduated with the degreee of civil engineer in 1884. He also earned the degree of master of arts, which was given him in 1887.

No professional work offering itself immediately upon graduation, he taught school one winter, but in the spring of 1885 he resumed railroad engineering with the Rock Island Railroad, going later to the Union Pacific, with which company he was employed until the fall of 1886. He then returned to his alma mater as assistant professor of engineering, which position he held, the title being subsequently changed to assistant professor of civil engineering, until 1903, when he was made professor and head of the Department of Municipal and Sanitary Engineering. This position he held until his death. He was also engineer to the County Board of Supervisors, having charge of their bridge work, which was extensive, and for eleven years he was city engineer of Iowa City, designing and having charge of the construction of its sewer system and a large mileage of paving.

He was a member of the Phi Delta Theta Fraternity, the Society of the Sigma Xi, the Iowa Engineering Society, and the Society for the Promotion of Engineering Education.

He was married July 13, 1887, to Minnie Sutliffe, four children being born of this union. He died November 14, 1907.

Modest and retiring almost to a fault, Professor Magowan never sought his own advancement by other ways than fidelity to his work and to those who employed him. Always faithful in service to the university, always faithful in professional work, always faithful in the many activities with which he had to do in his church, devoted to the interests of his students, known to be absolutely honest, he was called upon for far more than should have been required of one man. In the words of one of his students, "He did a *man's* work and lived a *man's* life."

STORM BULL,

Late Professor of Steam Engineering, University of Wisconsin.

Storm Bull was born at Bergen, Norway, October 20, 1856. His early education was obtained at his home in Norway, but for his professional training he went to Switzerland where he attended the famous engineering school at Zurich. He chose the course of mechanical engineering, from which he was graduated with the degree of M.E. in 1877. The cosmopolitan character of the institution was of great advantage to him as he was compelled to listen to lectures in two different language (French and German), both foreign to him. In this way Professor Bull laid the foundation for an exceptional proficiency in the use of modern languages, both in speaking and writing.

After graduation he spent two years in engineering practice, mostly in European shops. He came to this country in 1879 and chose Madison, Wis., as his residence. Shortly after his arrival he was appointed instructor in the engineering department of the University of Wisconsin, in which position his work varied from time to time as the contingencies of the program required. He was appointed professor of mechanical engineering in 1886; and, in 1891, because of increased specialization of work, he was made professor of steam engineering. This chair he held up to the time of his death.

Professor Bull's technical training was of the highest order, and his working knowledge of mathematics and methods of higher analysis was equalled by very few men in American engineering schools. First of all teacher and scholar, Professor Bull was also active in the practice of his profession and the performance of public and civic duties. He was an honored member of many scientific and technical societies, and was one of the most active among the organizers of this Society.

Devotion to duty was a strong element in his character, and to him it demanded his best service, not only in his profession of teacher and engineer, but in all of his relationships with society. It was this that led him to give generously of his time for several years as a member of the common council and as the Mayor of the City of Madison.

In the spring of 1907 Professor Bull was attacked by cancer and, while an operation appeared for a time to relieve the trouble, it returned, and after many months of suffering he passed away on November 17, 1907. He leaves a wife and one son, a recent graduate of the University of Wisconsin.

CHARLES PHILO MATTHEWS,

Late Professor of Electrical Engineering, Purdue University.

Charles Philo Matthews was born September 18, 1867, at Fort Covington, N. Y., and was at the time of his death a little more than forty years of age. His early education was received at St. Johnsburg Academy, St. Johnsburg, Vt., where he completed his academic training in 1887. He entered Cornell University and was graduated from the electrical engineering course in Sibley College in 1892. After his graduation he became an instructor in physics at Cornell, serving in that capacity until called to Purdue University as associate professor of electrical engineering in 1896.

In 1905 Professor Matthews was placed at the head of the School of Electrical Engineering, which position he held until his death, November 23, 1907.

Professor Matthews was a very successful teacher. He knew his work thoroughly, and presented it in a clear, concise, understandable manner. He was possessed of a personality which made him interesting, approachable and helpful. His fine sense of humor, insight into character and faculty of narration are well known to his friends.

Professor Matthews did much in scientific research, and made many contributions to scientific knowledge. He was particularly interested in photometry and in the subject of artificial illumination. His most important work of investigation was the photometric value of the enclosed arc lamp, a series of investigations conducted under the auspices of the National Electric Light Association. This extended over four years, and the reports cover several hundred pages. He was also the inventor of a number of devices for photometric measurements, and was the author of several text-books.

In 1906 Cornell University conferred on Dr. Matthews the degree of doctor of philosophy in recognition of his valuable contributions to scientific and engineering literature.

WILLIAM ARNOLD ANTHONY,

Late Professor of Physics and Electricity, and Director
of Physical Laboratories, Cooper Union for the
Advancement of Science and Art.

William Arnold Anthony was born in Coventry, R. I., November 17, 1835; he was graduated from Sheffield Scientific School, Yale University, with the class of 1860; he taught school in New England for a time, and then served several years as professor of physics and chemistry at Antioch College, Ohio, and later at the Iowa State College. In 1872 he was called to the chair of physics in Cornell where he remained until 1887. For five years he was consulting engineer to the Mather Electric Company, Manchester, Conn., and after 1893 he was professor of physics and electricity, at the Cooper Union for the Advancement of Science and Art, which position he held up to the time of his death.

Professor Anthony was the author, with Professor Brackett, of Princeton, of a well known text-book on physics, and also the author of "Notes on Electrical Measurements." He was the designer and builder of the first American dynamo machine—the well-known Gramme machine which has been exhibited at the expositions of Philadelphia in 1876, Buffalo and St. Louis. In 1875 this machine was used in regular service to furnish current for arc lamps on the campus at Cornell before such means of illumination had been introduced in any of the great cities of the world, and has been in continuous service ever since. Now, after a third of a century this interesting machine, which Professor Anthony constructed, is still in daily service furnishing power to the student shops in Cornell University. During its long life it has never needed repairs which could not readily be done in the work-shops of the department.

Professor Anthony made many contributions to scientific research, especially in the field of electric engineering where he did much pioneer work and also contributed much to the practical development of electrical engineering. But despite the high position he occupied in these fields, those who were fortunate enough to have been his students and those who had the pleasure of being associated with him as teachers and co-workers, will always believe that he was at his best, and did his greatest work as a teacher in the lecture room and laboratory where he was fired by that enthusiasm which is given only to those who thoroughly love their work.

Library
N. C. State College

INDEX.

ADAPTING MEANS TO THE ENDS IN TECHNICAL EDUCATION, by A. L. Rice 5, 121
Address of Welcome, by Mayor Thompson 16
Address, President's Annual, by C. S. Howe. THE FUNCTION OF THE ENGINEER IN THE CONSERVATION OF THE NATURAL RESOURCES OF THE COUNTRY 5, 20
Amendments, Constitutional Requirements Concerning lxix
American Society of Mechanical Engineers, Joint Meeting with .. 1
  Annual Spring Reception of 6
Anthony, G. S., THE CORRELATION OF THE COURSES IN ENGINEERING COLLEGES 5, 126
Anthony, William A., Obituary of 10, 15, 409
Assets, Report of 12
Auditing Committee 1
  Report of the 4
Baker, I. O., CEMENT LABORATORY PRACTICE 7, 216
Benjamin, C. H., Discussion 88
Boyd, J. E., Discussion 236
Brashear, J. A., CONTRIBUTIONS OF PHOTOGRAPHY TO OUR KNOWLEDGE OF STELLAR EVOLUTION 3
Breitenbach, H. P., Discussion 89
Bull, Storm, Obituary of 10, 15, 407
By-Laws lxix
CAREERS OF GRADUATES IN MECHANICAL ENGINEERING, by F. de R. Furman 8, 307
CEMENT LABORATORY PRACTICE, by I. O. Baker 7, 216
Committee, Executive lxix
  Joint, on Engineering Education 1, 7
  Nominating ....8, lxviii
  On Auditing Treasurer's Report, Report of 4
  On Conservation of Natural Resources 5
  On Degrees 5
  On Entrance Requirements for Engineering Colleges 1
  On Industrial Education 1, 7
  On Necrology, Report of 10, 15, 406
  On Resolutions, Report of 9
  On Revision of the Constitution 6
  On Statistics of Engineering Education 1
  On Technical Books for Libraries 1

Concentric Method in Engineering Education, by V. Karapetoff 7, 258
Constitution ... lxvii
  Report of Committee on Revision of the ... 6
Contents, Table of ... iii
Contributions of Photography to Our Knowledge of Stellar Evolution, by J. A. Brashear ... 3
Cooley, M. E., Discussion ... 298
Correlation of the Courses in Engineering Colleges, The, by G. S. Anthony ... 5, 126
Council, Constitutional Requirements Concerning ... lxviii
  Members of Present ... viii
  Members of Previous ... lxv
  Rules Governing the ... lxviii
Course in English in Technical Schools, The, by J. M. Telleen .. 3, 61
Date of Sixteenth Annual Meeting ... 1
Deceased Members ... lxiii
Discussions, Allowable Time to be Devoted to ... lxx
Drane, W. H., Should an Engineer be Required to Hold a License? ... 7, 350
Dues and Fees, Constitutional Requirements Concerning ... lxviii
Eddy, Hy. T., as Chairman of Nominating Committee ... 8
  Discussion ... 94, 247
Edmands, S. S., Electrical Laboratory Equipment and Efficiency ... 7, 202
Election of New Members ... 13
  Officers for 1908–09 ... 8
  Council for 1908–11 ... 8
Electrical Laboratory Equipment and Efficiency, by S. S. Edmands ... 7, 202
Ennis, W. D., On Entropy ... 7, 249
Estep, H. Cole, Discussion ... 94
Executive Committee ... lxix
Expenditures, Summary of ... 12
Fees and Dues, Constitutional Requirements Concerning ... lxviii
Fletcher, Robt., as Member of Committee on Resolutions ... 9
Frost, H., A Proposed Course in General Engineering ... 3, 98
Function of the Engineer in the Conservation of the Natural Resources of the Country, The, by C. S. Howe ... 5, 20
Furman, F. De R., The Careers of Graduates in Mechanical Engineering ... 8, 307
General Summary of Members ... lxii
Geographical Distribution of Members ... liii
  Summary of Members ... lviii
Goss, W. F. M., Second Degrees for Graduates in Engineering Courses ... 5, 159
  Discussion ... 92, 246

Hamerschlag, A. A., Discussion 93

Hibbard, H. W., Discussion 84, 173, 200

Honorary Members, Constitutional Requirements Concerning lxvii

Hood, O. P., as Member of Committee on Resolutions 9
  As Member of Auditing Committee 4

HOW FAR IS PURE THERMODYNAMICS OF VALUE IN PREPARING STUDENTS FOR HANDLING MECHANICAL ENGINEERING OR HEATING PROBLEMS, by A. J. WOOD 7, 238

Howe, C. S., THE FUNCTION OF THE ENGINEER IN THE CONSERVATION OF THE NATURAL RESOURCES OF THE COUNTRY 5, 20

Index 410

Industrial Education, Report of Committee on 363

Institutions Represented lix

Jackson, D. C., Report of Committe on Engineering Education ..2, 47
  As Member of Auditing Committee 4
  Discussion 92, 119

Jackson, J. P., SCHOLASTICISMS IN ENGINEERING EDUCATION ...5, 162
  Discussion 296

Joint Committee on Engineering Education, Preliminary Report of the, by S. Sheldon and D. C. Jackson 2, 47

Karapetoff, V., THE CONCENTRIC METHOD IN ENGINEERING EDUCATION 7, 258
  Discussion 157, 278

Kent, W., THE RESULTS OF AN EXPERIMENT IN TEACHING FRESHMAN ENGLISH 3, 74
  Discussion 96, 201, 236, 246, 277, 299

Landreth, Q. H., as Member of Auditing Committee 4

Leete, J. H., Discussion 302

Liabilities, Report of 12

Life Members, Constitutional Requirements Concerning lxvii

List of Council viii
  Of Deceased Members lxiii
  Of Members ix
  Of Members of Previous Councils lxv
  Of Officers Elected vii
  Of Past Officers lxiv
  Of Persons Elected to Membership 13
  Of Standing Committees vii

Magowan, Charles Scott, Obituary of 10, 15, 406

Magruder, W. T., PRESENT CURRICULA OF THE MECHANICAL ENGINEERING COURSE 3, 113
  Discussion 120, 306

Marston, A., Discussion 199

Matthews, Charles Philo, Obituary of 10, 15, 408

Mead, D. W., TECHNICAL INSTRUCTION IN HYDRAULIC ENGINEERING 7, 174

Meetings, Constitutional Requirements Concerning lxix

Members, Constitutional Requirements Concerning lxvii
  General Summary lxii
  Geographical Distribution of liii
  Geographical Summary of lviii
  List of Active ix
  Deceased lxiii
  Of Council, Present viii
  Of Council, Previous lxv
  Elected at Sixteenth Annual Meeting, List of 8
Name of Society lxvii
Necrology, Report of Committee on 10, 15, 406
Nominating Committee, Constitutional Requirements Concerning..lxviii
  Report of 8
Norris, H. H., THE USE AND ABUSE OF LANTERN SLIDES 7, 343
Occupations, Summary by lxii
Officers, Constitutional Requirements Concerning................lxviii
  List of, 1908–09 1
  Previous lxiv
ON ENTROPY, by W. D. Ennis 7, 249
Papers, Allowable Time to be Devoted to the Reading of lxx
Papers, Widest Possible Circulation of, Resolutions on 6
Past Officers, List of lxiv
PLACE OF MODERN LANGUAGES IN THE SCHOOL OF ENGINEERING, THE, by A. S. Wright 5, 136
Place of Sixteenth Annual Meeting 1
PRESENT CURRICULA OF THE MECHANICAL ENGINEERING COURSE, by W. T. Magruder 3, 113
President's Annual Address, by C. S. Howe 5, 20
Proceedings, Report of 1
Program Committee lxx
PROPOSED COURSE IN GENERAL ENGINEERING, A, by H. Frost 3, 98
Publications, Constitutional Requirements Concerning lxix
  Price of lxx
Raymond, Wm. G., as member on Committee of Resolutions 9
  Discussion 95
Receipts, Summary of 12
Reception, American Society Mechanical Engineers 6
Report of Auditing Committee 4
  Committee on Industrial Education 7
  Joint Committee on Engineering Education, Preliminary, by S. Sheldon and D. C. Jackson 47
  Nominating Committee 8
  On Necrology 10, 15, 406
  On Resolutions 9
  Proceedings 1
  Secretary, The 9
  Treasurer, The 11

Reprints lxx

Resignations During Year 1907–08 .... 10, 15

Resolutions on Widest Possible Circulation of Papers presented to Society 6

RESULTS OF AN EXPERIMENT IN TEACHING FRESHMAN ENGLISH, by W. Kent 3, 74

Revision of the Constitution, Report of Committee on 6

Rice, A. L., ADAPTING MEANS TO THE END IN TECHNICAL EDUCATION 5, 121

Rules Governing the Council lxviii

Schneider, H., TWO YEARS OF THE COOPERATIVE ENGINEERING COURSES, UNIVERSITY OF CINCINNATI 8, 279

  Discussion 295, 296, 297, 299, 304, 306

SCHOLASTICISMS IN ENGINEERING EDUCATION, by J. P. Jackson..5, 162

SECOND DEGREES FOR GRADUATES IN ENGINEERING COURSES, by W. F. M. Goss 5, 159

Secretary, Report of the 9

Sheldon, S., Report of Committee on Engineering Education 2, 47

SHOULD AN ENGINEER BE REQUIRED TO HOLD A LICENSE? by W. H. Drane 7, 350

Standing Committees vii

  Request for a Report 161

Summary of Members, By Occupation lxii

  General lxii

  Geographical liii

TECHNICAL INSTRUCTION IN HYDRAULIC ENGINEERING, by D. W. Mead 7, 174

Telleen, J. M., THE COURSE IN ENGLISH IN TECHNICAL SCHOOLS..3, 61

  Discussion 95

Time of Sixteenth Annual Meeting 1

Treasurer, Report of the 11

TWO YEARS OF THE COOPERATIVE ENGINEERING COURSES, THE UNIVERSITY OF CINCINNATI, by H. Schneider 8, 279

USE AND ABUSE OF LANTERN SLIDES, THE, by H. H. Norris 7, 343

Webb, J. B., Discussion 246

Wiley, W. O., Report of Treasurer 11

Williston, A. L., Report of Committee on Industrial Education..7, 363

  Report of Secretary 9

  Discussion 237, 300, 337

Wood, A. J., HOW FAR IS PURE THERMODYNAMICS OF VALUE IN PREPARING STUDENTS FOR HANDLING MECHANICAL ENGINEERING OR HEATING PROBLEMS? 7, 238

Woodward, C. M., Discussion 278, 294, 295, 305, 362

Wright, A. S., THE PLACE OF MODERN LANGUAGES IN THE SCHOOL OF ENGINEERING 5, 136